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June 2024
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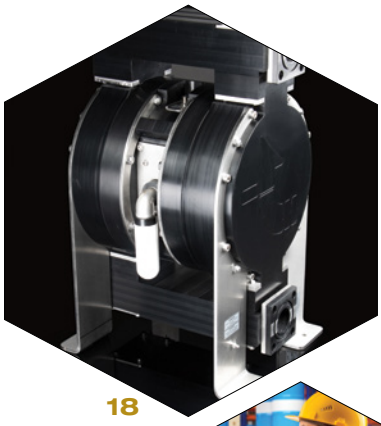

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Cover design: Tara Bekman
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Editor's Page

Tackling the plastics challenge

Plastic products have evolved to play a prominent role in our daily lives. They are generally durable and lightweight, making them ideal for a broad spectrum of applications, such as: improving efficiency of automobiles; extending the shelf-life of foods; providing insulation and sealants in buildings; use in household products, consumer electronics, medical equipment and more. The use of plastics has increased over the years, and according to the United Nations Environment Programme (UNEP; Nairobi, Kenya; www.unep.org), the world currently produces 430 million metric tons of plastics each year [*1*]. The increased use of plastics, however, has also resulted in an increase in waste plastic, much of which is ending up in the environment as plastic pollution.

INC-4

In late April, an international meeting was held in Ottawa to address the plastic pollution problem. It was the fourth session of the Intergovernmental Negotiating Committee (INC), a group aimed at developing an international legally binding instrument on plastic pollution, including in the marine environment. The Committee was formed in 2022 at the request of the executive director of UNEP to develop an instrument that addresses the full lifecycle of plastic, including its production, design and disposal. The Ottawa gathering (INC-4) was the Committee's largest, with over 2,500 delegates. One more meeting (INC-5) is planned for November in Busan, Republic of Korea. The end of 2024 is the deadline that was set for the Committee's work at the outset in 2022, making INC-5 the final scheduled meeting.

Progress was made at INC-4 in drafting text for a potentially international legally binding agreement. Discussions among the delegates included topics of emissions and releases, production, product design, waste management and more. The draft text reportedly includes the idea of limiting plastic production, even though there are strong objections to such limitations. Members agreed to continue their work in intersessional meetings to make more progress before INC-5 [*2*].

Producers focus on circularity

The U.S. Environmental Protection Agency (EPA; Washington, D.C.; www.epa.gov) estimates that only about 9% of all plastics are recycled in the U.S., although some specific polymers are recycled at a higher rate — polyethylene terephthalate (PET) and high-density polyethylene (HDPE) were recycled at about 29% in 2018.

Plastic producers are looking to more significantly reduce the waste problem through a circular economy, with recycling as a major component. The group America's Plastic Makers (www.plasticmakers.org), which is made up of the American Chemistry Council's Plastics Division and its member companies, has outlined a number of guiding principles, as well as a strategy of five policy actions, that would accelerate a circular economy. Details of both can be found on the group's website.

For continued up-to-date news on recycling, readers can subscribe to *Chemical Engineering*'s Sustainability e-newsletters at www.chemengonline.com. ■

Dorothy Lozowski, Editorial Director

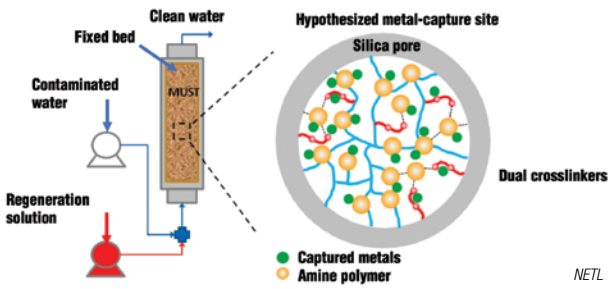
1. UNEP, Turning off the Tap: How the world can end plastic pollution and create a circular economy, May 16, 2023.
2. Sources: Associated Press, 5 takeaways from the global negotiations on a treaty to end plastic pollution, www.apnews.com; and UNEP, Road to Busan clear as negotiations on a global plastics treaty close in Ottawa, www.unep.org.

A versatile sorbent that can clean metals from wastewater at a lower cost

At the 2024 Spring Meeting of the American Institute of Chemical Engineers (AIChE; www.aiche.org), a team from the National Energy Technology Laboratory (NETL; www.netl.doe.gov) presented on a recently patented technology for the removal of critical and heavy metals from wastewater (diagram). The Multi-Functional Sorbent Technology (MUST) is composed of an epoxy-amine crosslinked polymer network immobilized within the pores of a silica support, explains NETL researcher McMahan Gray. When compared to activated carbon, a commonly used sorbent for recovery and removal of metals from water, MUST binds the metals much more strongly, while also being more selective toward specific metals. It also boasts a simple, one-pot preparation method that can be easily scaled, and is readily regenerable. According to the NETL, MUST costs around $300/ft^3, whereas competitive technologies may range from $500–800/ft^3.

MUST is produced via wet impregnation, which involves the suspension of silica particles in a dilute solution of amine, crosslinkers and solvent. "Then, pulling a vacuum under extended modest heating evaporates the solvent and completes the crosslinking reaction. This produces a dry, granular sorbent after only 1 h of total preparation time," says Gray.

An 18-kg batch of a single-crosslinker MUST formulation was produced by a commercial partner and used for the recovery of rare-earth elements, and a prior generation of the sorbent, which was used for CO_2 capture, was produced at the ton scale. "The sorbent was initially developed to treat fossil-related wastewaters, like acid-mine drainage and fluegas desulfurization wastewater. However, the sorbent was successful in removing metals like lead from tap water, manganese from simulated hydraulic fracturing water and various metals from nonaqueous waste streams, as well as natural and synthetic dyes. We further expect the sorbent to successfully remove per- and polyfluoroalkyl substances (PFAS)," adds Gray. The next step for MUST is a potential commercial partnership that will see the sorbent cleaning industrial-effluent waste streams.



Making cement with 70% lower CO_2 emissions

A process commercialized by Fortera Corp. (San Jose, Calif.; www.forteraglobal.com) creates a cement product that reduces CO_2 emissions by 70% on a ton-for-ton basis, and can be blended with conventional cement or used as a standalone material to make ready-mix concrete. Fortera recently opened a small commercial plant located in Redding, Calif. at the site of partner and conventional cement producer CalPortland Co.'s (Summerlin, Nev.; www.calportland.com) facility. The Fortera plant, which can produce 15,000 ton/yr of "green" cement, captures CO_2 emitted during cement production and permanently sequesters it by mineralizing the CO_2 into $CaCO_3$ in the cement mix, explains Fortera CEO Ryan Gilliam.

"Fortera's ReCarb process works within the existing cement-production infrastructure and reduces energy use by using a lower kiln temperature," Gilliam says. "This creates a path to zero-CO_2 cement when renewable energy is used at planned future plants, says Gilliam.

In Fortera's ReCarb process, limestone is heated in a kiln to make CaO, similar to conventional Portland cement, but the CO_2 from the kiln's fluegas and the CO_2 driven off in the formation of CaO is captured and directed back into the process. Milled CaO is conveyed to a dissolution reactor to dissolve the lime in a proprietary solvent. The dissolved calcium solution is transferred to a multiphase absorber reactor, where waste CO_2 from the plant is introduced to the solution to cause a precipitation reaction that forms a product the company calls reactive calcium carbonate (RCC; tradename ReAct).

The RCC is part of a slurry, from which the liquid is removed with a clarifier, followed by a filter press. The resulting solid cake is dried and broken into powder that can be blended with conventional cement or used alone.

Fortera's ReAct green cement is ASTM-approved, and exhibits the same strength and durability as ordinary cement, says the company. It will be available this summer for ready-mix suppliers.

Edited by:
Gerald Ondrey

E-CRACKING

Last April, BASF SE (Ludwigshafen, Germany; www.basf.com), SABIC (Riyadh, Saudi Arabia; www.sabic.com) and Linde Engineering (Pullach, Germany; www.linde-engineering.com) inaugurated the world's first demonstration plant for large-scale electrically heated steam-cracking furnaces. Following three years of development, engineering, and construction work, the regular operation of the demonstration plant is now ready to start at BASF's *Verbund* site in Ludwigshafen.

The demonstration plant, which produces olefins, such as ethylene, propylene, and possibly also higher olefins from saturated hydrocarbon feedstock, is fully integrated into the existing steam crackers in Ludwigshafen. In two separate demonstration furnaces, two different heating concepts are being tested. In one furnace, direct heating applies an electric current directly to the cracking coils. In the second furnace, indirect heating uses radiative heat of heating elements placed around the coils. The two electrically heated furnaces together process around 4 ton/h of hydrocarbon feedstock and consume 6 MW of renewable energy.

To support the development of the furnace technology, the project was granted €14.8 million by the German Federal Ministry for Economic Affairs and Climate Action under its Decarbonization in Industry funding program.

AMMONIA CATALYST

Researchers led by Satoshi Kamiguchi at the RIKEN Center for Sustainable Resource Science (CSRS; www.csrs.

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riken.jp) have discovered a catalyst that enables ammonia to be produced from H_2 and N_2 at relatively low temperatures. Described in a recent issue of *Chemical Science*, the catalyst works stably at a lower temperature (around 200°C), compared to 500°C (and 500 atm pressure) needed for iron-catalyzed Haber–Bosch process.

The biggest hurdle was breaking down the triple-bonded N_2. "The trick was to use ultrasmall molybdenum metal particles prepared from a hexanuclear molecular metal-halide cluster, which was then activated with hydrogen gas," says senior research scientist Satoshi Kamiguchi. Once activated, multiple Mo atoms work together to quickly break the strong N–N bonds and drive NH_3 synthesis. When tested, this catalyst was able to create NH_3 from N_2 and H_2 continuously for more than 500 h at 200°C.

The research team is now focusing on adding promoters to the Mo-based catalyst to make NH_3 synthesis more efficient.

RICE STRAW

Every year in Asia, around 300 million metric tons of rice straw are burned after harvesting. In an effort to reduce the environmental footprint, a new a new international collaboration — the Renewable, Inclusive Carbon-negative Energy (RICE) project, funded by Innovate U.K. Energy Catalyst program — has started, including researchers from Aston University (Birmingham; www.aston.

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New microreactors and flow loops improve asphaltene management

Asphaltenes are an ultra-complex fraction of crude petroleum that comprise a diverse population of molecules that vary in size, solubilities, aggregation states and hetero-atom contents. Asphaltene buildup and deposits create many operational and safety issues, and can occur anywhere in crude-oil production systems where favorable conditions exist. Despite their prevalence in the oil-and-gas industry, much is still misunderstood about asphaltene chemistry and control.

A new research initiative launched by ChampionX (The Woodlands, Tex.; www.championx.com) is designing new testing and evaluation methods to create more effective chemical formulations for asphaltene control that can be easily transferred from the laboratory to the field. "We are developing better methods that narrow the gap between asphaltene-control chemical performance in the laboratory and performance in field applications. By adopting better crude-oil storage and handling for asphaltene-control testing, the chemical development and qualification process can be improved substantially," says Chris Russell, corporate scientist at ChampionX.

To tackle these concerns, the team developed a high-pressure, high-temperature flow loop where asphaltenic crude oil is subjected to field-relevant temperature and pressure conditions in the presence of heptane or propane. "This system has differential-pressure monitoring capabilities and can provide a qualitative, real-time deposition risk prediction during test runs, enabling the optimization of chemical supply. We have also developed a new microreactor methodology for asphaltene-deposition evaluation. This test provides a rapid measure of asphaltene deposition that can deliver effective chemical formulations in more elaborate detail, even in field applications, to help in preserving the integrity of assets," explains Duy Nguyen, senior corporate scientist at ChampionX.

The asphaltene rocking-cell and flow-loop methods test the effect of different chemicals to provide qualitative risk assessment for asphaltene precipitation, agglomeration and deposition. Results of these tests support the selection of the optimal chemicals to treat each scenario. The team also developed a series of complex testing processes to address precipitation, agglomeration and deposition control. This research has highlighted the fact that synergistic combinations of kinetic asphaltene inhibitors with the correct concentration of dispersant can effectively control the size of asphaltene agglomerates.

On-demand electric heat can reach near-flame temperatures

Electrification provides an avenue for industrial decarbonization, but many electric-heating options cannot handle the high temperatures and scale required for industrial use. Electrified Thermal Solutions (ETS; Medford, Mass.; www.electrifiedthermal.com) has taken a new approach to industrial heating through its JouleHive thermal battery, which can achieve near-flame temperatures continuously without degradation. The heart of JouleHive is the company's proprietary electrically conductive fire bricks (E-bricks). "With all existing electric-heating options, the hotter you run them, the faster they will oxidize and break down. Our oxide bricks don't burn out like other electric heating options," explains Daniel Stack, CEO and co-founder of ETS.

To overcome the limitations of existing heaters with oxide bricks, ETS is employing alumina chromium mixtures for the foundation of the bricks, which are then subjected to a special series of doping techniques to enhance electric conductivity. "These are materials that are mass-produced today and are among the most chemically stable for operating with air and CO_2. Because we can operate in any of these gaseous environments, we avoid the need for inert environments and metallic heat exchangers. This is what allows us to run cheaper and be more scalable," says Stack.

The company currently operates an engineering-scale JouleHive system cycling at 1,700°C in an elevator-sized box filled with E-bricks. When electricity is applied to a JouleHive system — whether continuously or intermittently — the E-bricks convert it to heat, and by blowing air through it, on-demand hot gas is generated, which can flow to any kind of furnace, boiler or kiln. Plans are in place to install a commercial demonstration system at the Southwest Research Institute in San Antonio, Tex. this year. ETS and its partners Ashland Chemical and the Tennessee Valley Authority (TVA) were recently awarded a $35-million grant from the U.S. Dept. of Energy for a project to decarbonize steam generation at an Ashland production site. The project team estimates that this system's deployment could result in 70% decarbonization of the plant.

ac.uk) Straw Innovations Inc. (Laguna, the Philippines; streawinnovations.com) and Takachar (Dehradun, Uttarakhand, India; takachar.com). The project is focusing on rice production in India and the Philippines — the world's second and eighth largest rice producers, generating 130 million m.t./yr of both rice and straw.

Aston University and Straw Innovations are collaborating with Takachar (takachar.com), which has developed small-scale, low-cost, portable equipment that can convert agricultural waste on-site into higher value bioproducts, such as fertilizer blends, chemicals and biofuels.

Takachar will develop a supersized version, which is 10 times bigger than its current device, make it adaptable to rice mills, and will send it to Straw Innovations, so the two firms can test out different business models for farmer adoption and benefit. Straw Innovations will also send its machines from the Philippines to India mid-project and the two countries will test out different business models for farmer adoption/benefit. And, for the first time, they will tap into the heat produced in the waste process to dry rice, instead of using diesel or kerosene.

FLAX OIL

A way to make vegetable oils with more antioxidants, a longer shelf life and less-bitter taste has been developed at the University of Vienna (Austria; www.univie.ac.at). The university has filed a patent application for the process and a spin-off company, OFS Lipid Legends GmbH (Vienna, Austria; www.lipid-legends.com) has exclusive rights to the process and is already marketing an optimized flax oil.

The improved oil takes advantage of the natural ingredients left behind in the press cake remaining after the oil is first recovered from the seeds. The oil is used to naturally extract these ingredients from the cake, which enriches the oil with polyphenols. The polyphenols not only stabilize the unsaturated fatty acids, but also remove the bitter taste. The shelf life of the refined oil

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Isotope-enrichment process starts commercial production

Traditional isotope enrichment to separate radioactive atoms is highly capital intensive, and the supply chains for the materials are constrained, with the majority of enriching capability located in Russia. In a bid to expand isotope availability and lower costs, ASP Isotopes Inc. (Washington, D.C.; www.aspisotopes.com) recently began commercial production of isotopes at a facility in South Africa.

The company says it is now enriching ^{14}C and ^{28}Si isotopes using technology that drastically cuts the capital cost of separation and does not produce waste materials (radioactive or otherwise). ^{14}C is used for radiolabeling of compounds in biomedical research applications. And due to its improved thermal conductivity, isotopically pure ^{28}Si can help augment computer chip performance in quantum computing applications, for example.

The commercial isotope-separation technology, known as Aerodynamic Separation Process (ASP), has its origins in development work conducted around uranium enrichment in the 1980s in South Africa. In ASP, the material to be separated, in raw gas form, is injected at high speed (several hundred meters per second) tangentially into a stationary tube via specially sized and positioned openings in the tube's surface. ASP Isotopes says the gas then "follows a flow pattern that results in two gas vortexes occurring around the geometrical axis of the separator." In this way, isotopes can be separated by mass difference.

"Two ASP plants are now operating in South Africa, and a third is being built in Iceland, where we will take advantage of inexpensive energy to further lower enrichment costs," says ASP CEO Paul Mann.

In addition to the commercial aerodynamic separation process, ASP Isotopes is also building a facility for separating other isotopes, including ^{100}Mo and ^{68}Zn for computed tomography imaging applications, and ^{176}Yb for oncology treatment, among others. This technology, called quantum enrichment, separates isotopes by their differing ionization energies. A precisely tuned laser selectively ionizes one isotope species, which is separated by a charge collector.

The company is also developing the technologies for generating enriched ^{37}Cl, ^{6}Li and ^{235}U isotopes for use in nuclear energy applications, such as small modular reactors (SMRs).

Next-generation encapsulation technology

Nucleic acid-based medications, such as mRNA vaccines, are opening up new therapeutic approaches. These active ingredients must be enclosed inside nanoparticles to ensure that they get to where they are needed inside the body's cells. The Fraunhofer Institute for Production Systems and Design Technology IPK (www.ipk.fraunhofer.de) and FDX Fluid Dynamix GmbH (both Berlin, both Germany; www.fdx.de) have developed a technology platform — called Fraunhofer Dynamic Mixing Technologies (FDmiX) — for the production of nanoparticles that can achieve particle quality and stability at levels previously out of reach. Lonza AG (Basel, Switzerland; www.lonza.com) has licensed the patented technology for its own good manufacturing practice (GMP) production activities, and is already using it.

The heart of the FDmiX platform is an OsciJet nozzle from FDX Fluid Dynamix. Inside the nozzle, a jet of liquid is positioned on one of the sides of the main chamber. Before leaving the nozzle, a small part of the jet is deflected into a side channel. At the end of the side channel, it meets the main jet again and pushes it to the other side. This causes the main jet to oscillate continuously from one side to the other at a high frequency. In this way, the jet of lipid solution oscillating through the nozzle meets the stream of the mRNA active ingredient at a perpendicular angle, creating a homogeneous mixture with nanoparticles of uniform size. In tests of conventional impinging mixers (T- or Y-mixers), by contrast, the lipid solution and mRNA active ingredient collide before flowing together through the same channel. This creates a dynamic vortex, resulting in inhomogeneous particles of lower quality.

The oscillating flow in the FDmiX enables 6–8 times faster and more reliable mixing. This results in improved critical quality attributes (CQAs) and higher yields thanks to consistent nanoparticle size and fewer filtration losses. The system is scalable, because encapsulation can take place with volume streams ranging from 5 mL/min to 1.5 L/min without affecting the particle properties.

Extracting useful proteins from beer-brewing leftovers

Brewers' spent grain (BSG) is the most significant byproduct of the beer-brewing industry, making up 85% of the total waste. Globally, about 36.4 million ton/yr of spent grain are produced. This spent grain is typically discarded after its primary use in brewing beer. While some efforts are made to repurpose BSG in applications, such as animal feed, biofuel production or composting, a substantial portion still ends up in landfills, generating greenhouse gases, such as methane and CO_2.

After exploring new uses for the BSG proteins, researchers from Nanyang Technological University, Singapore's (NTU Singapore; www.ntu.edu.sg) Food Science and Technology (FST) program have developed a method that extracts over 80% of the available protein in BSG. The researchers say their protein-extraction method could help reduce waste, and the extracted proteins could be used to enrich diets and even for cosmetic applications.

The extraction method, described in a recent issue of *Innovative Food Science and Emerging Technologies*, is called microwave-assisted, three-phase partitioning (MATPP). The BSG is first fermented with a food-grade fungus, *Rhizopus oligosporus*. The fermented BSG is dried and ground into a powder, then blended with water and strained through a cloth to form a crude BSG extract (CBE). After microwave treatment, the CBE is saturated with ammonium sulfate, then *t*-butanol is added. This mixture is then vortexed, allowed to settle and finally centrifuged to form three phases. The upper (organic) and lower aqueous phases are removed, leaving the solid intermediate layer, which is collected and lyophilized. One kilogram of BSG yields 200 g of protein.

The researchers note that BSG proteins are safe for human consumption and of high quality, making them suitable for direct use in supplements and for enhancing the protein content of plant-based foods. The proteins were also found to be rich in antioxidants, which could not only protect human skin from pollutants, but could also extend the shelf life of cosmetics, such as body lotions and moisturizers.

The NTU FST team will be in discussion with Heineken Asia Pacific to scale up their protein-extraction method, and plans to collaborate with several food-and-beverage and cosmetic companies to further implement their technology, with an eye towards commercialization.

is said to be almost 40% longer than conventional oil.

TOXICS

Researchers at Chalmers University of Technology (Gothenburg, Sweden; www.chalmers.se) and the University of Gothenburg (www.gu.se) have developed an artificial-intelligence (AI) method that improves the identification of toxic chemicals — based solely on knowledge of the molecular structure. The method can contribute to better control and understanding of the ever-growing number of chemicals used in society, and can also help

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reduce the amount of animal tests.

The method is based on transformers, a type of AI model for deep learning that was originally developed for language processing. Transformers can identify properties in the structure of molecules that cause toxicity, in a more sophisticated way than has been previously possible.Using this information, the toxicity of the molecule can then be predicted by a deep neural network. Neural networks and transformers belong to the type of AI that continuously improves itself by using training data — in this case, large amounts of data from previous laboratory tests of the effects of thousands of different chemicals on various animals and plants.

The method is described in a recent issue of *Science Advances*.

CARBON NEUTRALITY

Syensqo SA's (Brussels, Belgium; www.syensqo.com) Kallo-Beveren production facility has achieved carbon neutrality by running exclusively on renewable energy. The facility produces Syensqo's Ryton polyphenylene sulfide (PPS) specialty-polymers.

The transition covers the complete decarbonization of the plant with regard to direct (Scope 1) and indirect (Scope 2) emissions under the Greenhouse Gas (GHG) Protocol. It is in line with the company's targets to reduce emissions by 40% by 2030 and be carbon neutral by 2040. ❐

Functionalized ionic liquids enhance L-L extraction of Ga and Ge

Gallium and germanium are considered critical materials due to their multiple uses in semiconductors, optics, healthcare and pharmaceuticals, and other high-technology applications. Current solvent-based extraction methods for recovering these elements suffer from significant drawbacks, such as low separation efficiency, poor selectivity and the generation of large amounts of waste solvents.

Research at the Missouri University of Science and Technology (MST; Rolla, Mo.; www.mst.edu) is aimed at addressing those drawbacks. Lana Alagha, associate professor of mining engineering at MST, and colleagues were recently awarded a grant of $875,000 from Rio Tinto (London, U.K.; www.riotinto.com) for a two-year project to develop technology that uses functionalized ionic liquids (ILs) for extraction of Ga and Ge from aqueous waste products resulting from copper mining.

"Functionalized ILs have task-specific ligands that facilitate the metal extraction by a solvation mechanism, rather than by an ion-exchange mechanism, thus extending the lifetime of the extractant and eliminating the need for a costly saponification process," explains Alagha in a patent covering the technology. Complexing functionalities are incorporated into both anionic and cationic parts of the ILs, and researchers can change the anion and cation of the IL to tailor the structure and target specific metals, Alagha says.

"The inner synergistic effect provided by both cation and anion helps to improve the loading capacity and kinetics of the extraction process," allowing enhanced recovery and separation of Ga and Ge, Alagha notes. "There is currently little-to-no production of these two elements in the U.S., and we rely to an alarming extent on importing them." ■

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Business News

Plant Watch

Asahi Kasei starts operation of multi-module hydrogen pilot plant in Japan

May 14, 2024 — Asahi Kasei Corp. (Tokyo; www.asahi-kasei.com) opened a new hydrogen pilot plant in Kawasaki, Japan. In the pilot plant, four 0.8-MW electrolyzer modules are being operated under realistic conditions, including operation during maintenance and low-power supply during nighttime. In addition, the equipment is designed to simulate fluctuating power input from solar or wind power. With its multi-module approach, Asahi Kasei aims to combine up to ten modules with a capacity of 10 MW each, enabling commercial large-scale electrolysis systems with a capacity of up to 100 MW.

BASF to expand additive production capacity in Nanjing

May 13, 2024 — BASF SE (Ludwigshafen, Germany; www.basf.com) plans to invest in the expansion of its advanced additives plant at its Nanjing, China site. This expansion includes the addition of a new production line for BASF's controlled free-radical polymerization (CFRP) dispersants. The new line is planned to start up by the end of 2025.

Climeworks opens world's largest direct-air capture plant in Iceland

May 9, 2024 — Climeworks AG (Zurich, Switzerland; www.climeworks.com) started up the world's largest direct-air CO_2-capture and storage plant, located in Iceland. It is the second commercial facility built by Climeworks in Iceland and is about ten times larger than its predecessor. The plant is designed for a nameplate CO_2-capture capacity of up to 36,000 metric tons per year (m.t./yr). The plant is built in a modular design, with twelve of its total 72 collector containers currently installed onsite. More modules will be added throughout 2024.

Wacker expands production capacity for biopharmaceuticals in San Diego

May 7, 2024 — Wacker Chemie AG (Munich, Germany; www.wacker.com) announced that its subsidiary, Wacker Biotech US, is increasing production capacity and adding new laboratory facilities at its biopharmaceuticals manufacturing facility in San Diego, Calif. With this investment, the site's capabilities to produce plasmid DNA (pDNA) via fermentation will be enhanced and further scaled.

Bp's Archaea Energy starts up modular RNG plant in Kansas

May 6, 2024 — Bp plc (London; www.bp.com) announced that its Archaea Energy business started up its largest modularly designed renewable natural gas (RNG) plant in Shawnee, Kan., just outside of Kansas City. The plant, which is fully owned by Archaea, is located next to a large, privately owned landfill. The Shawnee plant can process 9,600 std. ft^3/min of landfill gas into RNG, tripling the capacity of Archaea's RNG plant in Indiana, which started up in October 2023.

DOMO Chemicals opens new polyamide production plant in China

May 2, 2024 — DOMO Chemicals GmbH (Leuna, Germany; www.domochemicals.com) inaugurated a new polyamide plant in Haiyan, Jiaxing, Zhejiang, China. With a €14-million investment, the new plant will increase the site's current polyamide production capacity of 25,000 m.t./yr to 35,000 m.t./yr and eventually to 50,000 m.t./yr in the long term.

Carbios breaks ground on first PET biorecycling plant

May 2, 2024 — Carbios (St-Beauzire, France; www.carbios.fr) held a groundbreaking ceremony for the world's first biorecycling plant for polyethylene terephthalate (PET). Located in Longlaville, France, the plant will have a processing capacity of 50,000 m.t./yr of prepared plastic waste when operating at full capacity. It is expected that commercial quantities of recycled product will be available from the plant in 2026. The plant will employ Carbios' enzymatic recycling technology.

Syensqo to open North America's largest PVDF production plant in Georgia

April 26, 2024 — Syensqo S.A. (Brussels, Belgium; www.syensqo.com) broke ground on a new battery-grade polyvinylidene fluoride (PVDF) facility in Augusta, Ga. When complete, the site will be the largest PVDF production facility in North America, supplying the growing needs of domestic energy-storage markets. The site is estimated to produce enough PVDF for more than 5 million electric-vehicle batteries per year at full capacity, or 45% of expected PVDF demand required by 2030.

Linde increases production capacity for industrial gases in Florida

April 26, 2024 — Linde plc (Guildford, U.K.; www.linde.com) increased the capacity of its industrial-gas production facility in Mims, Fla. Linde has expanded production capacity at Mims by 50%, following similar projects that doubled output in 2020 and 2021. In addition to expanding capacity, the Mims facility reduced Scope 2 greenhouse-gas emissions by 15%. The additional capacity will deliver oxygen, nitrogen and argon to users in the healthcare, manufacturing, food-processing, aerospace and water-treatment sectors.

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Mergers & Acquisitions

Ashland to sell its nutraceuticals business

May 8, 2024 — Ashland Global Holdings Inc. (Wilmington, Del.; www.ashland.com) agreed to sell its nutraceuticals business to Turnspire Capital Partners LLC. Ashland's nutraceuticals business supplies a broad portfolio of active ingredients and formulation aids to nutritional product companies, as well as custom-formulation and contract-manufacturing capabilities, from four production facilities in New Jersey, Utah and Tamaulipas, Mexico.

Shell to sell interest in Singapore Energy and Chemicals Park

May 8, 2024 — Shell Singapore Ltd., a subsidiary of Shell plc (London; www.shell.com), has reached an agreement to sell its Energy and Chemicals Park in Singapore to CAPGC Ltd., a joint-venture (JV) company between Chandra Asri Capital Ltd. (www.chandra-asri.com; Jakarta, Indonesia) and Glencore Asian Holdings Ltd. (Singapore). The transaction will transfer all of Shell's interest in Shell Energy and Chemicals Park Singapore to CAPGC. The Shell Energy and Chemicals Park Singapore comprises integrated petroleum refining and chemicals assets on Pulau Bukom and Jurong Island. The Pulau Bukom assets include a 237,000-bbl/d petroleum refinery and a 1.1-million-m.t./yr ethylene cracker.

Arkema acquires Dow's packaging adhesives business

May 2, 2024 — Arkema S.A. (Colombes, France; www.arkema.com) signed an agreement with Dow, Inc. (Midland, Mich.; www.dow.com) to acquire Dow's flexible-packaging laminating-adhesives business, which provides adhesives for the flexible packaging market, generating annual sales of around $250 million. The acquired business operates five production sites in Italy, the U.S. and Mexico.

Imerys to acquire diatomite and perlite business from Calgon Carbon

May 2, 2024 — Imerys S.A. (Paris; www.imerys.com) began negotiations with Chemviron, a subsidiary of Calgon Carbon Corp. (Moon Township, Pa.; www.calgoncarbon.com), to acquire its European diatomite and perlite business. With this acquisition, Imerys would acquire three mining and industrial facilities in France and Italy that serve users in the food, filtration and pharmaceutical markets. In 2023, the diatomite and perlite business generated around €50 million in revenue.

Mitsubishi and Denka to form JV for production of fullerenes

April 25, 2024 — Mitsubishi Corp. (MC; Tokyo; www.mistubishi.com) and Denka Company Ltd. (Tokyo; www.denko.co.jp) signed a JV agreement under which Denka will acquire from MC a 50% stake in Frontier Carbon Corp. (FCC), a company that manufactures and sells fullerenes. Fullerenes are nanoscale allotropes of carbon, whose single or double-bonded atoms are joined together in rings in spherical form. They have excellent conductive and thermal properties and can be dissolved in common organic solvents at room temperature, making them effective conductors in solar cells. ■

Mary Page Bailey

the

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Advanced Column Internals Support Energy Efficiency

New packings and trays encourage effectiveness and energy efficiency in traditional and emerging applications

Equipment for distillation, absorption, stripping, extraction and phase separation plays a major role in the chemical process industries (CPI). However, separation processes are notoriously energy intensive, which is far from ideal with the current movement toward sustainability across all CPI sectors. Compounding the problem, operational challenges such as bottlenecks, fouling and corrosion often plague the towers and columns used for separations.

The good news is that today's advanced column internals allow greater levels of energy efficiency, fewer operational challenges and more effective separations in traditional applications, while also paving the way for newer sustainability-based carbon capture, waste recovery and biofuel operations.

Efficiency and throughput

"The desire to reduce energy consumption is increasingly being expressed by operating companies worldwide," says Neil Sandford, global technology leader — trays, with Koch-Glitsch, LP (Wichita, Kan.; www.koch-glitsch.com).

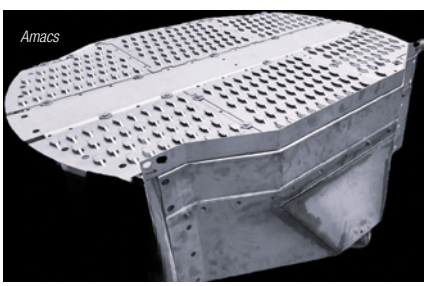

FIGURE 1. Amacs' Scalloped Edge Mini Valve (SEMV) trays feature scalloped edges that split the vapor into multiple smaller streams to enhance vapor/liquid contact, reducing entrainment and pressure drop

"Separations are energy-intensive processes and the design and operation of the column internals can have a significant impact on overall energy consumption."

Sandford continues: "New mass-transfer technologies provide improved performance and efficiency, so there are many opportunities in existing processing units to replace outdated equipment with newer technologies to achieve higher throughput with lower pressure drop and reduced energy requirements due to improved efficiency. These technologies can be applied in various ways to achieve the goals of the tower, unit and plant."

Dean Segal, vice president of sales and marketing with Pope Scientific Inc., (Saukville, Wis.; www.popeinc.com) agrees that debottlenecking and retrofit projects are a growing trend. "The biggest challenge in these projects is the tradeoff between purity and yield and what that comes down to is the number of theoretical plates possible within a certain height and the inherent pressure drop that exists. In higher columns, the pressure drop can become so great that it is not viable," Segal continues. "For this reason, there are various packings and trays that provide different characteristics and there are ways to be smarter about the design and operation of the overall system."

Moize Turkey, vice president, engineering, with Amacs Process Tower Internals (Houston; www.amacs.com) adds, "In applications where we are retrofitting to achieve a 15 to 20% increase in capacity, there are two options: to increase the size of the tower or to use higher capacity, higher efficiency internals to keep the tower size smaller and reduce energy consumption. It is usually more economical to debottleneck towers with high capacity, high efficiency retrofit solutions as long as the entire system is looked at holistically."

"Before focusing on the tray or packing, you need to understand the entire system and the constraints of the column, as well as the capacity target and other factors. Once you know what is needed and what issues may exist upstream and downstream of the unit, it becomes easier to develop a design and select high-efficiency, high-capacity internals that meet the end needs," explains Babak Rafi, technology manager — mass transfer, with Amacs.

Fortunately, providers of column internals are developing a variety of high-efficiency, high-performance solutions, so there is likely to be a suitable option for most applications.

For example, Amacs offers its Scalloped Edge Mini Valve (SEMV) trays in which the scalloped edge feature splits the vapor into multiple smaller streams to enhance vapor-liquid contact, reducing entrainment and pressure drop (Figure 1). The valves can be fabricated as either fixed or float valves depending on application requirements.

"They are designed in such a way that breaking the vapor stream into smaller jets reduces pressure drop and increases capacity, while also achieving a better efficiency, providing a double impact of reducing entrainment and increasing output while improving the efficiency of each tray," explains Rafi. "This is why we can achieve a smaller foot-


Koch-Glitch

FIGURE 2. To accommodate the need for higher capacities and better efficiency, Koch-Glitsch offers Flexipak HC structured packing, which can provide higher capacities, lower pressure drops and increased efficiency compared to conventional structured, grid and random packing types

print in diameter and tower height to achieve the efficiency and output that are needed."

For packed columns, both structured and random packings are available to boost efficiency and performance, but the selection depends on many factors within the application.

"The advantage of random packings is a better redistribution due to sharp edges of the geometry itself," says Daniel Borchardt, team leader of process technology with Raschig GmbH (Ludwigshafen, Germany; www.raschig.com). "In the past it was assumed that structured packings offer less redistribution property so a redistributor after a certain active column height was usually considered. However, the use of a redistributor eliminates the advantage of a structured packing reaching a higher specific capacity and wider operational range compared to a random packing with an equivalent specific surface due to directed flow guidance."

He continues to say that Raschig executed pilot trials with the result that the outlet flow above the structured packing bed does not show a bigger droplet size distribution. Instead, it may be caused by the rotation of each packing element that takes place during installation. "Therefore, existing plants that are filled with random packing could be improved by using a structured packing and new commissions could have lower capital costs."

To that end, the company offers Super-Pak structured packing. Unlike previous structured packing designs, there are no sharp directional flow changes within the Raschig Super-Pak element. Rows of sinusoidal waves within the vertical packing sheets are surface enhanced to encourage greater turbulent radial spread of thin liquid-film flows on the front and back of the waves on each sheet within a packing element.

The open structure achieves improved hydraulic and mass-transfer efficiency characteristics and loading capacity is high, with improved separation, while pressure drop remains low during normal operation.

To accommodate the need for higher capacities and better efficiency in a variety of applications, Koch-Glitsch offers several options: Flexipak HC structured packing (Figure 2), Proflux severe service grid and Intalox Ultra random packing, which can provider higher capacities, lower pressure drops and increased efficiency compared to conventional structured, grid and random packing types that may still be used in processing units. "Sometimes simply changing the packing can achieve higher throughput or higher product quality in existing processing units, while in new towers, these can be applied to reduce column diameter and height to lower the capital cost of the project."

And, Performance Distillation Solutions (PDS; Bellefonte, Pa.; www.pdspropak.com) offers its Pro-Pak random packing (Figure 3) in applications where space is limited or high numbers of theoretical plates are required. "The small height equivalent to theoretical plates (HETPs) provided by the packing allows columns to be much shorter for a similar number of theoretical stages," says Jason Paloskey, technical sales manager with PDS.

Pro-Pak is used where high purity, space saving, energy saving and low-loading design are critical considerations, because they provide greater efficiencies for better separation and higher free space to ensure lower pressure drop.

Solving operational challenges

While efficiency and throughput are indeed significant challenges, fouling, corrosion and ultra-low liq-


PDS

FIGURE 3. Pro-Pak random packing from Performance Distillation Solutions is used where high purity, space saving, energy saving and/or low loading design are critical considerations.

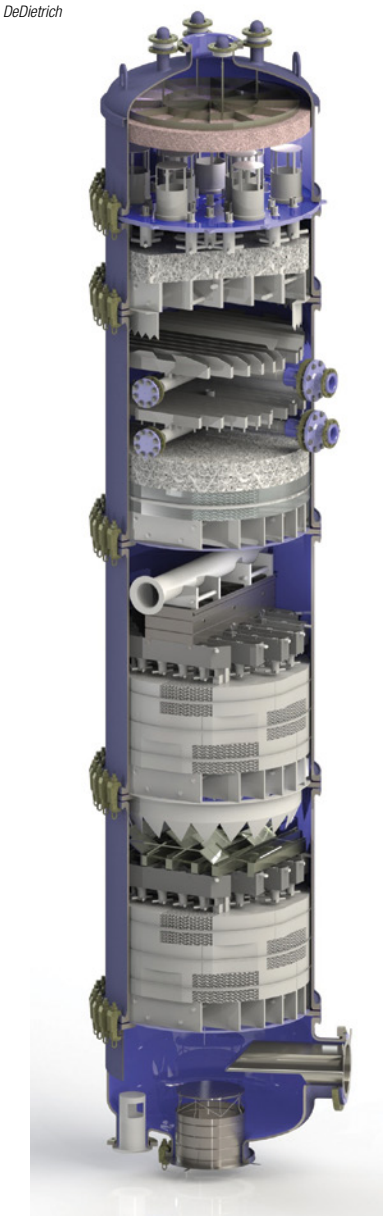
DeDietrich

FIGURE 4. DeDietrich offers high-performance column internals made of high-corrosion-resistant materials like borosilicate glass, glass-lined steel, Tantalum, Si-ceramics and fluorinated plastics, like PTFE. This cross-section illustration showcases various technology offerings

uid load conditions are often prevalent in chemical separations. Fortunately, advanced technologies are available to reduce these issues.

Koch-Glitsch offers a range of solutions to lessen the impact of fouling, including fouling-tolerant tray designs using large, fixed valves like the Provalve tray, which offers a strong forward pushing action to keep the potential foulants moving down the tower.

Corrosion is also a major challenge in chemical separations and internals made of stainless steel or certain plastics will not work within highly corrosive media, says Rainald Pabst, sales product manager, columns and internals, with DeDietrich Process Systems GmbH (Mainz, Germany; www.dedietrich.com). For this reason, DeDietrich offers high-performance column internals made of high-corrosion-resistant materials, such as borosilicate glass, glass-lined steel, Tantalum, Si-ceramics and fluorinated plastics like polytetrafluoroethylene (PTFE) (Figure 4).

"These materials are more corrosion resistant in difficult, heavy chemical industries, such as mineral acid recovery plants than Hastelloy or other metallic packings, but offer nearly the same pressure drop and behavior as metallic structured packings," says Pabst. "We can combine highly corrosion-resistant materials with structured packings to solve the challenges of new separation processes but also find that customers who have been operating columns for 30 or 40 years with older packing styles come to us for these modern packings with higher efficiency and throughput, as well as corrosion resistance."

Raschig also offers its Raschig-Pak Ceradur (Figure 5), a special ceramic packing with a unique chemical composition that results in superior chemical resistance and provides an alternative to more expensive packings.

And, Sulzer Chemtech (Winterthur, Switzerland; www.sulzer.com) has developed a unique hybrid gauze structured packing, AYPlus DC (Figure 6), to overcome the issues associated with ultra-low liquid load operating conditions. In these conditions, it is challenging to have adequate liquid spreading and wettability on the surface of structured packings, which leads to a significant drop in efficiency. Sulzer's packing AYPlus DC offers excellent wettability even for an aqueous system with high surface tension, the company says.

The performance has been tested in Sulzer's R&D test center in Winterthur, witnessed by an independent research institute, and has been successfully proven in the field in nearly 100 installations. In combination with Sulzer's MellaTech ultra-low liquid load distributor, AYPlus DC outperforms equivalent metal-sheet structured packings with up to three times more efficiency while meeting requirements in terms of capacity and pressure drop. The packing improves the performance and reduces energy consumption of various highly relevant aqueous applications with low liquid load, such as the drying column in an ethylene glycol plant.

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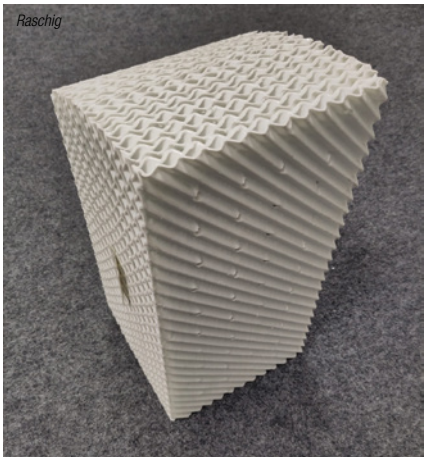

Raschig

FIGURE 5. Raschig-Pak Ceradur is a special ceramic packing with a unique chemical composition that results in superior chemical resistance and provides an alternative to more expensive packings

Sustainability projects

Thanks to these advancements in column internals, mass-transfer equipment will continue to play a critical role in sustainable and green applications. "Columns, packing and internals are very important for decarbonization efforts and mass transfer has been used to capture CO_2 for years in various applications such as gas processing, hydrogen production, ammonia production and fertilizer plants," says Koch-Glitsch's Zack Bondley, global technology leader — packing. "The solvent technology is very mature in these applications and it is a common and effective process. The units operate at higher pressures and have higher concentrations of CO_2 than the post-combustion carbon-capture units to capture CO_2 from fluegases."

According to Bondley, post-combustion carbon capture units operate close to atmospheric pressure. The amount of fluegas at the low operating pressure results in very large absorber towers and the energy required from the blower in these large units requires a low-pressure-drop media in the absorber tower to make it economically viable. "While traditional structured packing was typically used in these applications, there was a need for improved packing to help reduce the absorber column size, both in height and diameter without increasing the pressure drop."

Koch-Glitsch developed Flexipak CP structured packing specifically for the needs of CO_2 absorber towers. "The structured packing provides options to tower height due to its improved capture efficiency and reduces the diameter due to increased capacity and lower pressure drop, allowing the capital cost of the CO_2 absorber tower to be greatly reduced," says Bondley. "Alternatively, the same-sized tower can also be used for a dramatic reduction in the pressure drop to reduce the operating cost of the carbon-capture unit."

Sulzer's packing AYPlus DC finds use in post-combustion carbon capture plants. In these applications, a once-through design in the water wash section of a CO_2 absorber to reduce the solvent emissions to sub-ppm (parts per million) and even down to parts per billion (ppb) levels is made possible with this packing. Compared to the traditional design, which requires two pump-around units, the advanced design offers better efficiency and lower capital costs. In combination with MellapakCC structured packings and tailored MellaTech column internals, the performance of the CO_2 absorber is maximized while the plant's capital and operational expenses are minimized.

MellapakCC is Sulzer's structured packing family for carbon capture. This packing family has performed in numerous industrial-scale columns across various carbon-capture plants, including power plants, cement, steel, petroleum-refinery and petrochemical facilities, with the largest column diameter exceeding 7.5 m.

And, PDS's Pro-Pak packing and column internals have been used as a mass-transfer medium in both scrubbing columns and stripping columns, allowing the transfer of gases into a waste stream and aiding in the transfer out of a carrier fluid, according to Paloskey. "Further, applications involving cryogenic distillation of CO_2 and/or CO_2-rich streams can benefit from the high efficiency of Pro-Pak, reducing size and, thus, the amount of energy needed to cool the system — a double win!"


Sulzer Chemtech

FIGURE 6. Sulzer's AYPlus DC offers excellent wettability to overcome issues associated with ultra-low liquid-load operating conditions, where it is challenging to have adequate liquid spreading and wettability on the surface of structured packings

In addition to carbon-capture applications, trays, packings and column internals are required for applications such as sustainable biofuels and waste-to-chemical applications.

For example, Raschig developed a unit to turn plastic waste to chemicals using advanced structured packing. "In this customer's application, the pyrolysis-oil upgrade unit improves the quality of the produced pyrolysis oil, which is a liquid that is made from hard-to-recycle plastic waste that would otherwise end up in a landfill," explains Raschig's Borchardt. "The cleaned and treated pyrolysis oil raffinate/product is used in an ethylene cracker to produce a wide range of chemicals, closing the recycle loop. This plant is already built and expected to be in operation by the third quarter of 2024. All the extraction columns are equipped with structured packings without a redistributor in the active section."

And, high-efficiency and high-capacity trays or packings can significantly enhance separation and purification of biofuels, such as bioethanol and biodiesel, says Amacs' Rafi. "Using advanced internals reduces energy consumption in these applications and makes these energy sources more reliable and more common, which is essential because energy consumption is a critical factor in the production of biofuels and makes it most cost-efficient. There is a direct relationship between unit performance and the use of more alternative energy sources, such as biofuels. Advanced internals can help make this possible." ■

Joy LePree

Focus on Pumps

SPX Flow

Eldex

NAVAC Vacuum

KSB

This positive-displacement pump has optimized efficiency

The Universal 2 ND positive-displacement pump (U2 ND) Series (photo) significantly expands the WCB pump range, aimed at enhancing reliability and performance, while outperforming other pump styles, such as industrial lobe, gear or progressive-cavity pumps, the company says. The pumps ensure a long running life, given their robust construction materials and designs tailored for each application. Because of its high volumetric efficiency, the pumps can be used to dose fluids, eliminating the need for an additional metering pump. The U2 ND pump reduces slip, which occurs when fluids move backward from the liquid flow due to internal clearances. Lower slip means more efficiency, reducing the need for higher-horsepower motors. Also, the series can process fluids over longer spans due to its high-pressure capability, which reduces the need for multiple pumps in these applications. — *SPX Flow, Inc., Charlotte, N.C.*
www.spxflow.com

Pump accessory heats metering pump's head

The Hot Head accessory (photo) directly heats the pump head up to temperatures of 250°F to improve flow dynamics when pumping viscous or waxy liquids. It was designed to provide easy access to head and valves to reduce maintenance downtime compared to heat-tape or water-bath solutions, saving users time and money. An integrated bi-metal thermostat automatically shuts down if temperature exceeds 300°F. The accessory operates with 120 and 240 V a.c. power for simple implementation worldwide. — *Eldex Corp., Napa, Calif.*
www.eldex.com

A rotary-vane vacuum pump with energy-saving features

The EcoDrive series of rotary-vane vacuum pumps features an adjustable gas-ballast valve, a forced oil-circulation system and an anti-suckback design. The series' signature model, the ED16 (photo), delivers a 16 m^3/h flowrate and an ultimate vacuum down to 4×10^{-3} mbar. A key feature for the EcoDrive series is the application of a high-efficiency brushless d.c. (BLDC) motor and control. In addition to its higher efficiency compared to conventional a.c. motors, BLDC is an inverter-driven d.c. motor, which can run at variable speeds. Also, its Eco Mode significantly reduces speed, thus conserving energy while maintaining vacuum level. When the Eco Mode is activated on an ED16, the motor speed will be reduced by one third, therefore reducing power consumption. — *NAVAC Vacuum, Lyndhurst, N.J.*
www.navacvacuum.com

Submersible pump for moving large volumes of water

AmaCan D (photo) is a new submersible pump in discharge tube with an open multi-vane impeller. Its main application is transporting large volumes of municipal or industrial water, as well as wastewater from stormwater, drainage and irrigation pumping stations. When selected with optional corrosion-resistant and abrasion-resistant materials, the new series can also be used in water pollution and flood control or in seawater aquaculture systems. The pump generates a maximum flowrate of 8,000 m^3/h and a maximum discharge head of about 30 m. The highest motor rating available as standard is 340 kW. All electric motors are of an efficiency corresponding to class IE3 for standardized motors to IEC 60034-30. Two bi-directional mechanical seals reliably prevent water ingress into the motor space. — *KSB SE & Co. KGaA, Frankenthal, Germany*
www.ksb.com

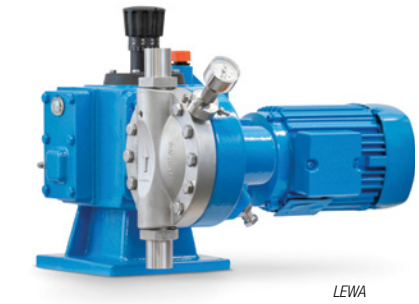
Corrosion-resistant couplings for chemical-transfer pumps

The stainless-steel ASK Couplings (photo, p. 19) feature a unique "sliced" body structure, making them an effective low-cost, corrosion-resistant solution that can accommodate many types of misalignment com-


Miki Pulley

monly found in chemical-transfer pumps. The one-piece ASK Coupling design compensates all types of system misalignment in a shaft-to-shaft connection. The sliced design handles high rotation speeds in the high temperature ranges experienced in chemical processing systems. The coupling's aerodynamic profile decreases noise while optimizing performance at high speeds. ASK couplings are easily configurable to accommodate a wide range of DBSE (distance between shaft ends). Bores can be arranged with clamp, split-collar or keyed styles for specific application requirements. — *Miki Pulley, Plymouth, Minn.*
www.mikipulley-us.com

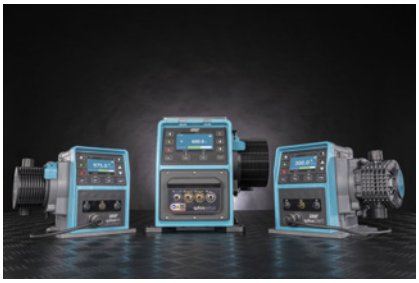
A new diaphragm metering pump for higher flowrates


LEWA

The ecosmart diaphragm metering pump has provided flowrates of up to 1,000 L/h. Now, the company has expanded its product range with the new, powerful LCD variant. The model is designed for a flowrate of up to 2,000 L/h. The maximum permissible operating pressure is 50 bars. The stringent use of similar components within the ecosmart range keeps production costs and therefore, the final price, low. At the same time, a high level of safety can be guaranteed by focusing on all essential design features, such as the pressure-relief valve or the proven sandwich diaphragm with diaphragm monitoring. The ecosmart pump can be aligned either vertically or horizontally (photo), making it easier to integrate the unit into systems with a very small footprint. In addition, the pump head of the new LCD variant is aligned at right angles to the plunger axis, resulting in a particularly compact format. — *LEWA GmbH, Leonberg, Germany*
www.lewa.de

A new chemical-metering and dosing pump

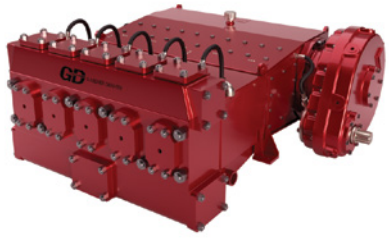
The Qdos H-FLO chemical metering and dosing pump (photo, p. 20) is designed for higher flowrates than other Qdos pumps, delivering up to 158 gal/h (600 L/h) and pressures up to 102 psi (7 bars). Qdos H-FLO features a variety of pump heads and a range of different tube materials to ensure chemical com-



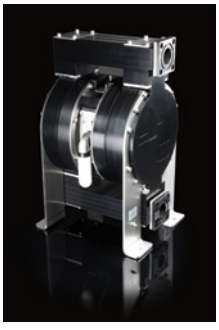
Watson-Marlow Fluid Technology Solutions

Edwards

Nidec Motor



GD Energy Products



Timmer

patibility with the process fluid. The Qdos H-FLO high-precision pump offers flexibility to be scalable with a user's process, whether it is in water and wastewater treatment, mining and mineral processing, chemical applications in the food-and-beverage or pulp-and-paper sectors. Like the rest of the Qdos range of peristaltic pumps, Qdos H-FLO cuts costs through higher-precision chemical metering, with an accuracy of ±1% and repeatability of ±0.5% in dosing. — *Watson-Marlow Fluid Technology Solutions, Falmouth, U.K.*
www.wmfts.com

The latest generation dry claw vacuum pump

Introduced early last year, the nEDC300 dry claw vacuum pump (photo) boasts a range of inventive attributes that not only boost performance, but also minimize noise levels, improve reliability and facilitate on-site maintenance. This means that it can be used in a wide range of applications, such as water and wastewater treatment, thermoforming, vacuum conveying, food processing or even in medical systems. In these processes, the dry claw pump guarantees its users a reliable, cost-effective operation with easy maintenance options. In addition to its modular design, a separate, insulated pump element makes the inside of the pump easily accessible to users for maintenance, repairs and cleaning. This means that the nEDC claw pump can be cleaned quickly and easily by the user. — *Edwards Ltd., Burgess Hill, U.K.*
www.edwardsvacuum.com

Enhanced line of vertical-pump motors for severe duty

This company has expanded its line of Totally Enclosed Fan Cooled (TEFC) vertical motors, with a new medium-high thrust motor (photo, p. 18). This U.S. Motors products are available in frame sizes 182 through 286 and are engineered for use in severe-duty environments. The motors drive pumps that are used in many different industries, such as water and wastewater, petrochemical, power and mining. They feature improved conduit box sealing, cast-iron frame, brackets and fan cover guard, and through-the-bearing lubrication for better expelling of used grease, which extends motor life and is particularly critical for vertical motors. The motors also include an option to meet API 610 driver requirements. — *Nidec Motor Corp., St. Louis, Mo.*
www.nidec.com

These HDD pumps feature an enhanced fluid-end design

The GD 800HDD pump (photo) is a compact, lightweight pump featuring an extremely high rod load and delivers a flowrate of over 1,000 gal/min. The new fluid-end design employs the company's patented Falcon retaining technology, which makes it easier to service and maintain the pump. This design accelerates valve changeout time by more than fivefold, resulting in reduced maintenance downtime during operations. In addition, costly third-party replacement parts that accompanied the previous "cage-style" valve design are eliminated, which enables improved operational efficiencies and streamlined procurement. All of the GD 800HDD pumps, which serve a wide variety of horizontal directional drilling (HDD) applications, will now utilize the new fluid-end technology. — *GD Energy Products, Houston*
www.gdenergyproducts.com

These diaphragm pumps are designed for chemical service

The tim CHEM double-diaphragm pumps (photo) are equipped with a plastic housing of either polyethylene (PE) or — for high chemical resistance — polytetrafluoroethylene (PTFE). Instead of the common practice of using threaded sleeves that are screwed into the plastic housing, this company uses a design that connects the highly-resistant plastic components that are in contact with media by means of tie rods. The force exerted by the tie rods is distributed by the large-area reinforcement plates — a measure that significantly minimizes deformation of the plastic caused by temperature variations. The company's tim FIX system uniformly distributes the forces of the tie rods and minimizes plastic deformation, and thus reduces the possibility of leaks. The pumps have only four sealing

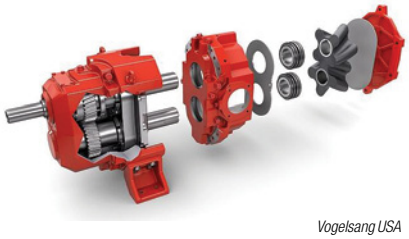
points, compared to up to 12 in other designs. This also reduces the possibility of leakage. The 2-in. version (photo, p. 20) has a maximum flowrate of 600 L/min. — *Timmer GmbH, Neuenkirchen, Germany*
www.timmer.de

A single-use micropump for microdosing applications

PSG Biotech

The Quattroflow QB2-Standard (QB2-SD) micropump (photo) is the smallest size in this company's family of single-use, lightweight and compact rotary microdosing pumps. The pump is designed for precision and can be used to transfer delicate biologic media. The QB2-SD has a minimum resolution of 25 µL and can handle flowrates up to 2.7 L/h, which makes the QB2-SD pump suitable for liquid-handling operations requiring precise dosing of products that can be found in cell and gene therapy, laboratory and other small-scale applications. The positive-displacement pump is lightweight (6.4 g) and compact. These single-use pumps simply click in and out of the motor drive, allowing for quick and cost-effective change-overs with minimal risk of cross-contamination. — *PSG Biotech, Oakbrook Terrace, Ill.*
www.psgdover.com/biotech

A new line of rotary-lobe pumps for the CPI



Vogelsang USA

The recently launched EP series of positive-displacement rotary-lobe pumps (photo) was designed around the typical requirements of industrial pumping applications. The EP series handles extreme conditions and constant high pressures. A heavy-duty gearbox allows for a uniform pressure output of up to 260 psi (18 bars). These pumps consist of a one-piece housing that can reliably pump abrasive, chemically aggressive and explosive flow media at temperatures of up to 392°F (200°C). Helical gears in the gearbox ensure smooth performance and reduce noise emissions. Pulsation-free conveying reduces wear on the adjacent pipeline while providing a low-shear pumping action. The EP series is equipped with an AirGap for high operational reliability. The AirGap atmospherically separates the gearbox and pump chamber, ensuring that in the event of a leak, the liquid will drain off to the outside rather than leaking into the gearbox. The AirGap also protects the gearbox when pumping high-temperature media. — *Vogelsang USA, Ravenna, Ohio*
www.vogelsang.info/en-us

Gerald Ondrey

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Cooling Tower Basics

Department Editor: Scott Jenkins

Most modern chemical processes require some means of rejecting heat for maintaining process efficiency, product quality and plant safety. Examples of heat rejection include cooling crystallization liquid, cooling reactor effluent, condensing material from a distillation column and cooling steps in manufacturing processes.

Heat-transfer fluids, including water, can absorb heat from machinery or heated process material in circulating cooling systems in industrial facilities, but the water must be cooled before it can be recirculated through the system. Cooling towers provide a means to release this excess heat into the atmosphere, allowing the water to return to a suitable temperature for reuse in the process. This one-page reference reviews the basic operating principles and performance parameters for industrial cooling towers.

Evaporative cooling

Industrial cooling towers are special types of heat-transfer equipment designed to reject heat from water to air by direct contact. Water is usually chosen as the cooling medium because it is the least expensive and most widely available option. Cooling towers receive warm water from the process and return cooled water at a specific design temperature. The water's temperature is lowered via evaporative cooling, where evaporating liquid carries heat away from the bulk liquid. Contact between warm water and cooler air releases the latent heat of vaporization, causing the water to cool. Ambient air carries the evaporated water out of the cooling tower.

The warm water is often sprayed to increase air-to-water contact and evaporation. The sprayed water contacts ambient air, evaporation occurs and and the humidity of the outgoing air increases (Figure 1). Maximizing the water-to-air weight ratio increases the evaporation of the water.

Since an increased quantity of water evaporating generates more cooling, airflow in the cooling tower is an important parameter. In mechanically induced-draft cooling towers, a fan is used to force air upward through the fill media. Natural-draft cooling towers use natural convective flow to circulate air.

Cooling-tower elements

There are several different commonly used cooling tower arrangements. But most have the following basic components.

Distribution system: Spray nozzles distribute warmed water over the fill media.

Fill media: Fill media are structured materials designed to maximize the contact area between air and water. Often made from polyvinyl chloride (PVC) or other materials, such as stainless steel, polypropylene or fiberglass, the fill media provide a high surface area for air-water contact.

Cooled water basin: After passing through the fill media, cooled water is collected in a basin at the bottom of the cooling tower.

Fans. Fans are often used in cooling towers to induce airflow and increase the rate of evaporation.

Drift eliminator: Drift eliminators are parallel blades arranged on the air-discharge side of the cooling tower. They are designed to reduce the loss of entrained water exiting the cooling tower with the airstream. Air passes through drift eliminators relatively unhindered, but water droplets contact the blades and drip back to the basin.

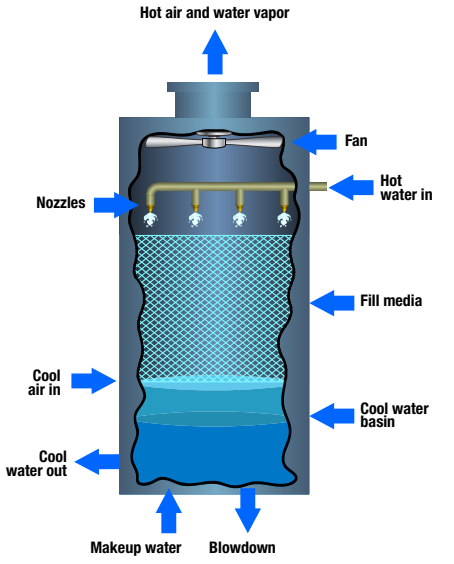

FIGURE 1. Cooling towers provide a means of releasing excess heat to the environment so cooling water can be recirculated through a system

Cooling tower key terms

The following terms are relevant for describing cooling-tower operation and performance.

Cooling range. Cooling range is the difference in temperature between the hot water entering the tower and the cooled water leaving the tower.

Approach. The approach represents the difference between the temperature of the cooled water leaving the tower and the wet-bulb temperature of the surrounding air. The establishment of the approach fixes the operating temperature of the tower and is the most important parameter in determining both tower size and cost.

Dry-bulb temperature. Dry-bulb temperature is the ambient air temperature.

Wet-bulb temperature. The wet-bulb temperature is lowest possible temperature the air can reach when air and water come into contact with each other, and is an indication of the heat content of the air.

Relative humidity. Relative humidity (RH) is the ratio between the amount of water vapor actually present in the air, and the maximum amount of moisture the air can hold at that temperature. At 100% RH, no more water can evaporate into the air from the surrounding environment.

L/G ratio. This is the liquid (water) to gas (air) mass flow ratio.

Blowdown: As cooling-tower water is circulated and water evaporates, total dissolved solids, including salts and scaling minerals concentrate in the water. Before the concentration gets too high, some water is removed and replaced with fresh water. This process is termed blowdown.

Drift. Drift refers to the water entrained in the airflow and discharged into the atmosphere. Drift loss does not include water lost by evaporation.

Makeup water. Makeup water is the amount of water required to replace normal losses caused by bleed-off, drift and evaporation. ■

Managing 'First-of-a-Kind' Projects

Developing a new technology from idea to commercial production involves major risks. Presented here are tools that project-management teams can use to mitigate them

Sebastiano Giardinella, Stephanie Brownstein, Jason Dietsch, Leslie Gioja, Kevin O'Brien
University of Illinois at Urbana-Champaign

IN BRIEF

Technology development in the chemical process industries (CPI) involves designing and building facilities for which there is uncertainty about not only the technical requirements for implementation, but also the performance of the process and the costs to build and operate the facilities.

Project managers in charge of developing first-of-a-kind facilities face the challenge of controlling scope, schedule and budget, while also achieving performance targets and maintaining risks under tolerable levels, in an environment where previous project data are non-existent, and many aspects of the project must be inferred or assumed from related (but different) projects. The often resource-intensive nature of CPI facilities compounds this challenge, since typical demonstration projects could reach the millions, tens of millions (or in some cases, hundreds of millions) of dollars in costs. An unsuccessful demonstration could break a company, especially if it is a technology-focused startup.

For this reason, technology demonstration projects in the CPI often follow a stage-gate approach, with different decision points that seek to validate the initial assumptions and the technology's feasibility. The goal of each stage should be to achieve a milestone that advances the technology readiness level (TRL) of the prospective technology. Each gate also presents a funding point, because each subsequent stage will be more capital-intensive, as the technology progresses from the laboratory to commercial scale.

This article describes the stages needed to develop a technology in the CPI from idea to commercialization (Figure 1) and provides an outline of the major risks involved in each stage and tools that the project manager may use to mitigate them.

TRLs and technology maturation plans

When a new technology is in development, it is highly advisable (and often required, if the research and development is partially funded by a government agency) to assess the status of its maturity against an accepted benchmark. The TRL scale, originally created for the U.S. space program, presents a general framework to assess the technology. The TRL scale is now widely employed in different settings and has been adapted to different types of projects. Table 1 shows the definitions utilized by the U.S. Department of Energy (DOE; Washington, D.C.; www.energy.gov) [*1*] and the European Commission (EC; Brussels; Belgium; commission.europa.eu) [*2*] on funded research and development programs. An example project progression would be the following:

- Basic experimental or paper research to understand the principles that set the foundations for the technology (TRL 1)
- Analytical work used to identify one or more practical applications (TRL 2)
- Laboratory-scale studies at the component level to validate analytical predictions combined with modeling and simulation (TRL 3)
- Rough integration of the components at a laboratory scale to compare experimental results against expected system performance under laboratory conditions (TRL 4)
- Integration of the components to a laboratory-scale system with a similar configuration to that of the final application, tested in conditions that replicate those of the final intended use (TRL 5)
- Scaling up to an engineering-scale model or prototype, testing in an environment similar to the one expected in industrial conditions, and evaluation of experimental results in the context of determining the requirements for a full-size operational system (TRL 6)
- Final design completion, construction and cold commissioning of a full-scale prototype (TRL 7)
- Hot commissioning, startup and operation of the full-scale prototype (TRL 8)
- Continued operation of the system in its final form under the full range of operating

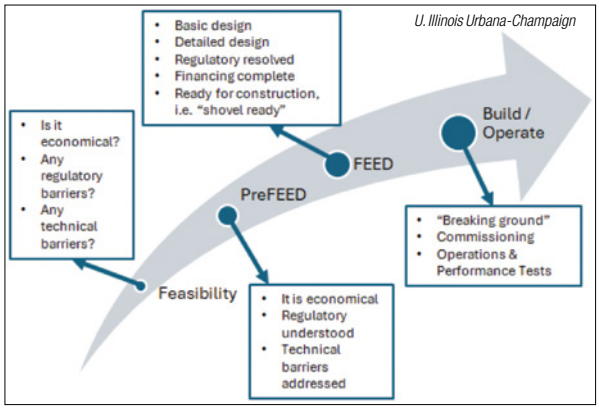

FIGURE 1. The diagram represents a typical progression for a chemical process industries (CPI) project, moving from initial investigations of an idea to commissioning and operation of a facility

conditions (TRL 9)

The goal of the technology developer is to transition the technology to TRL 9. The path to accomplish this is a compromise between several constraints, which include time, budget and risk. For example, a transition from laboratory scale directly to commercial scale may seek to save time and cost by skipping intermediate pilot-scale tests, but at the risk of potential cost overruns or financial losses if key operational and performance parameters have not been adequately assessed. On the other hand, relatively mature components of the technology whose performance and cost can be accurately predicted using simulation models or widely accepted engineering practices may not need to undergo intermediate validation steps.

To determine the best path to advance the technology, the developer may want to prepare a technology maturation plan (TMP). The TMP is a living document, the intent of which is to define the steps necessary to progress technology from its current TRL to commercialization.

When assessing the TRL of a system, it is often advisable to separate the entire process into subsystems and components (in the CPI, this could refer to breaking down into unit operations or process blocks) and assess the TRL level of each individual subsystem using the scale in Table 1.

After evaluating the TRL of each subsystem or component, the developer coordinates with their R&D team what work needs to be performed for each to progress to commercialization. The R&D team will often find that several components or subsystems have already achieved a high TRL or are commercially available and will choose to focus on the steps needed to increase the TRL of the systems that are less developed. At one point, however (typically when aiming to achieve TRL 6), the entire system will need to be integrated and designed at a scale that will allow assessing operational performance.

The subsystems and components identified in the TMP will be used as a basis to estimate the resources and time needed to progress to the next level of technology readiness. The TMP evolves with the TRL of the technology, with each step to maturate the technology being more intensive in resources.

Table 2 shows a relative scale, fidelity and environment comparison for each TRL, as recommended by DOE [*1*]. In the table, the term "identical" means the test matches the final application in every respect. "Similar" means a match in almost every respect. The term "pieces" means a match to parts of the final application. And "paper" means the involves no actual hardware.

The next sections describe some of the typical work performed on each scale to improve the TRL.

Background research (TRLs 1–2)

Before committing resources toward laboratory work, the R&D team should perform an extensive literature review of the idea to understand the underlying principles, collect published data (including previous patents, material properties, reaction kinetics and thermodynamics, solubilities, equilibrium constants) or proprietary data that was developed inside the organization. The team should also define the properties of the raw materials and the required

TABLE 1. TECHNOLOGY READINESS LEVELS FOR U.S. DEPARTMENT OF ENERGY AND E.U. EUROPEAN COMMISSION

TRL level	U.S. DOE [*1*]		E.U. EC [*2*]
	Relative level of technology development	TRL definition	TRL definition
TRL 9	System operations	Actual system operated over the full range of expected mission conditions	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)
TRL 8	System commissioning	Actual system completed and qualified through test and demonstration	System complete and qualified
TRL 7		Full-scale, similar (prototypical) system demonstrated in relevant environment	System prototype demonstration in operational environment
TRL 6	Technology demonstration	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 5	Technology development	Laboratory scale, similar system validation in relevant environment	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 4		Component and/or system validation in laboratory environment	Technology validated in laboratory
TRL 3	Research to prove feasibility	Analytical and experimental critical function and/or characteristic proof of concept	Experimental proof of concept
TRL 2	Basic technology research	Technology concept and/or application formulated	Technology concept formulated
TRL 1		Basic principles observed and reported	Basic principles observed

TABLE 2. TESTING RECOMMENDATIONS TO THE TRL (SOURCE: REF. 1)

TRL	Scale of Testing	Fidelity	Environment
9	Full	Identical	Operational (Full range)
8	Full	Identical	Operational (Limited range)
7	Full	Similar	Relevant
6	Engineering/Pilot	Similar	Relevant
5	Laboratory	Similar	Relevant
4	Laboratory	Pieces	Simulated
3	Laboratory	Pieces	Simulated
2		Paper	
1		Paper	

quality of the product, along with any other desired performance or cost targets (for example, to achieve a lower thermal consumption or a lower unit cost of product than commercially available competing technologies). Any gaps in the data are documented, since they can potentially become sources of technical risk. With said information, the team can now perform a paper study to visualize a production process capable of reaching the desired product quality with the available raw materials, utilizing the underlying principles of the technology.

Commercially available computer-simulation software can be employed (and is highly recommended) at this stage. Simulation tools can be used from molecular physics modeling of materials involved, to overall chemical process simulation, up to detailed fluid dynamics for a specific component in the system. These computer simulation tools typically contain a wide database of known component data or allow for experimental data to be incorporated when available. Some software tools also have models that allow estimating some component properties when neither database nor experimental data are available, but this introduces a higher degree of uncertainty in the results.

An initial optimization and alternatives analysis can begin at this stage, along with a preliminary assessment of process performance and unit cost of production for each potential process configuration. A sensitivity analysis should be performed over variables that have a high degree of uncertainty to assess the impact on the target process performance. An initial patent novelty search can be performed to identify potential improvements of the proposed process(es) over the state of the art.

Ideally, the result of this paper study should be at least one (and better yet, several) potential process configurations that can meet the desired performance and cost targets and be sufficiently different from existing technologies as to be patentable, along with a work plan for laboratory- and bench-scale experiments.

Lab- and bench-scale (TRLs 3–5)

Laboratory- and bench-scale testing should seek to fill all gaps in data from the component, reactions, or critical process steps, as well as verify the assumptions used in the initial paper study, and reduce the uncertainty in computer models, performance and cost estimates. Where applicable, testing procedures should adhere to standard methods, especially for characterization of materials.

Experimental work will involve procurement of materials (reactants, catalysts, reagents, consumables and so on), instruments and equipment. The instruments should have specifications, accuracy, resolution and sensitivity proper to the tests to be performed and be able to work under the expected range of test conditions. The equipment, from glassware to rotating and static equipment (including pumps, heat exchangers, mixers and so on) should be selected according to adequacy for the service requirements in all test conditions, and controllability. The assembly should include insulation, especially when measuring thermodynamic or kinetic data, to avoid errors due to heat transfer with the environment. Use of data acquisition systems and computer controls are recommended, especially at bench-scale testing.

Some reactants or raw materials, especially those with widely varying compositions or derived from non-commercial or non-standard mixtures

TABLE 3. TYPICAL RISKS ASSOCIATED WITH DIFFERENT TRLS

Risks	TRLs affected	Measures to mitigate risks
Key performance parameter (for example, component properties, reaction rate, selectivity, efficiency) unknown for target raw materials or operating conditions	1–4	•Literature search to find published results from relevant previous work •Computer simulation of the entire production process, utilizing measured data from bench scale experiments (for example, component properties, reaction or equilibrium data) •Laboratory or bench-scale experimental work to gather unknown data at expected operating conditions, utilizing samples from the expected raw materials (or synthetic samples that closely resemble the composition)
Technology's performance (for example, efficiency, rate, selectivity, specific energy consumption, emissions intensity and so on) not performing as expected in commercial scale	4–9	•Computer simulation of the entire production process, utilizing measured data from bench scale experiments (for example, component properties, reaction or equilibrium data) •Review of commercially available equipment and unit operations design and operating conditions and performance, to assess the performance of individual process steps •Engineering design, construction and operation of pilot scale model of commercial plant to measure data at relevant operating conditions and using said data to update computer models •Scaleup study, including pre-front-end-engineering design (PreFEED) or FEED of full scale facility to identify process and utility requirements, integration with existing facilities (if working on brownfields or revamping existing plants), and obtain more accurate estimates of overall plant performance
Economic / cost risks		
Uncertainty in capital and operating costs resulting in risk that the project will not be economically feasible, or the product competitive	2–9	•Develop capital, operations and maintenance cost models, and project financial projections, and update them with the results of scaleup studies •Benchmarking studies to identify costs of plants and products using competing technologies, to have a point of comparison •Sensitivity analysis to assess impact on costs from key performance or cost inputs and identify range of parameters where technology or product are economically feasible or competitive •Develop different cost models for different use cases, sourcing strategies, origin of utilities or ownership models
Unforeseen cost escalations during plant construction could strain budget or risk the project running out of funds before completion	7–9	•Develop a detailed cost estimate for each component of the project, including permitting, engineering, procurement, construction, commissioning and operations, including escalation and costs of financing during construction period •Allocate contingency funds to address unexpected cost increases •Participate in public or private competitions or grant programs, to pursue partial funding for the pilot- or full-scale demonstration facilities
Environmental, Health and Safety		
Full-scale plant may create risks from byproducts, waste materials, effluents, or emissions handling	6–9	•Environmental, health and safety risk analysis taking into account expected byproduct, waste, effluent and emissions composition from simulation models and engineering designs •Literature review for material safety data sheets (MSDS), environmental and work regulations, to identify hazardous substances and include control measures in the design •Consider adjacent communities, natural reserves, and other environmental aspects when selecting a site for the pilot- and full-scale plants
Risks to worker health and safety from first-of-a-kind process	6–9	•Design to accepted codes and standards relevant to the type of process, equipment and operations involved •Perform process hazards analysis (PHA) – for example, HAZID, HAZOP – during the engineering design stage, to identify risks to personnel along with control measures, and include control measures in the design •Operator training focusing on safe operations, and provision of adequate personal protective equipment •Proper definition of emergency escape routes, operational protocols, safety instrumented systems actions, and proper location of detection, alarm and response devices
Management and planning risks		
Unrealistic planning base/assumptions in project schedule may result in delays of project implementation	2-9	•Rolling-wave planning whereby activities close to execution are planned in detail and activities to be executed in future phases are planned in progressive detail based on inputs from activities in progress •Clear and carefully planned timeline created in collaboration with designers and engineers •Scenario-based planning, using conservative assumptions and adequate contingency time for activities on the critical path of the project •Bottom-up planning of individual activities
Delays due to difficulties in obtaining permits	6–9	•Begin engagement with local and environmental authorities during planning stage to identify permitting requirements and timelines •Identify any potential R&D exclusions that could allow to expedite permit processing
Pushback from neighboring communities	6–9	•Stakeholder analysis to identify key stakeholders and members of the community, along with potential interests that may be affected by project •Assessment of potential benefits or drawbacks of the project over the community, along with plans for stakeholder engagement and maximization of positive outcomes for community
Difficulty in securing skilled staff during execution phase	7–9	•Define organizational structure and required number of staff at each skill level for construction and operations phase •Obtain data from contractors, census, local government or work organizations on the quantity and skills of workers surrounding the project •Perform training programs to upskill workers to the level required for plant operations •Consider starting early on staffing, if there is a foreseen risk that skilled worker availability will be low in project location
Intellectual property (IP) and data risks		
Proprietary data leaks	1–9	•Control of project data in secure location administered by organization and with access only to project team •Identification of several types of data (for example, confidential, restricted rights, publishable), along with procedures for their tagging and protection •Limit information exchange with third-parties to what is absolutely necessary to achieve projects, and share confidential data only after non-disclosure agreements (NDAs) are signed
Risk that technology is non-patentable or that it breaches previous patents	2–5	•Patent novelty search to identify related patents and previous disclosures and assess patentability of technology •Identify all potential embodiments of the technology (including the method, system, as well as the materials or fluids involved), along with all innovative elements that could set the basis for claims in a patent application •If jurisdiction allows provisional patent application (for example, in the U.S.), consider filing it to obtain an early filing date, while some of the details of the technology are being determined (as long as no significant changes are expected, and this does not undermine efforts to secure protection in other jurisdictions) •Work with technology / IP office of organization, or with external patent attorneys to file provisional or non-provisional patent application as early in the process as possible

(for example, solid waste, effluents, fluegas), can be simulated by utilizing synthetic samples created in the laboratory by mixing commercially available standard compounds. These synthetic samples allow testing the system performance against variations in source materials quality to identify any correlation between system output variables and said inputs.

Initial laboratory tests can utilize batch processing, where individual subsystems or unit operations are tested, and their outputs are fed to the following unit operations in the process, but bench-scale tests should progressively aim to integrate the subsystems until they are able to replicate a continuous or semicontinuous process. At this point, the R&D team should seek to run the bench-scale plant at conditions, and with materials, that more closely resemble those expected in a real-life environment (or under conditions that are close enough to be considered relevant).

Once the laboratory and bench-scale testing has concluded, all gaps of information about the physical, chemical, thermodynamic and kinetic behavior of the process should have been addressed. At this point, the initial computer-simulation models should be revisited and adjusted. The technical and economic performance of the process should be reassessed, with a lower level of uncertainty, and a concept of both a pilot-scale and a full-scale facility should be developed on paper. The concept for the pilot-scale facility will be part of the work plan for the next level of technology maturation.

Pilot process (TRL 6)

The next step in technology maturation consists of designing, building and operating a pilot plant. To design the pilot plant, an adequate scale should be selected (DOE recommends a typical of 1/10th the capacity of a commercial full-scale facility, though the scale could be adjusted depending on the system on evaluation [*1*]). The capacity of the pilot facility could also be defined in terms of the smallest available commercial component, when defining the process around a critical technology, or by the capacity of a module, if the project design team is thinking on a modular scaleup strategy.

The pilot-plant facility design should follow the regular engineering design process utilized for designing a conventional plant, with some caveats, as stated here:

- If possible, it is recommended to design the pilot plant in a manner similar to a skid-mounted packaged unit. This would enable temporary installation at different test sites to widen the range of relevant conditions where the full-scale unit is expected to operate, while also allowing convenient removal of the pilot unit from the test site after the tests have been completed.
- The design should consider adequate flexibility in operating flowrates, temperatures and pressures, and adequate controls to adjust these to cover a wide range of conditions, as expected in results.
- The design should ideally consider strategically located removable spools, isolation valves, spectacle blinds, and other facilities to enable quick maintenance access, replacement of parts, or on-the-go modifications if required (this is particularly important when the process handles solids, sludge, precipitates or similar substances that may present material handling, plugging, freezing or transport problems as operations begin).
- If the plant is expected to be tested under varying weather conditions (or transported to different locations), the design of the facilities should consider the range of expected extreme conditions and include measures for winterization, tropicalization or other. Electric heat tracing or steam jackets could be considered if the plant will not typically be expected to operate under extreme winter but could be installed temporarily at a location with very cold temperatures.
- In some cases, the pilot-plant design can exclude utilities (unless the utilities form an integral part of the technology, such as in waste-energy recovery from the process). In this case, the utilities balance should consider the quantities and specifications of utilities (such as steam, compressed air, nitrogen, natural gas, electricity) that the plant will require to

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operate. When possible, these could be sourced from the test location if it has excess capacity, or from temporary facilities (for example, temporary electrical interconnection, or rental equipment) put in place for each test run. If the utilities are to be sourced from third parties, then instrumentation should be in place to measure the quantity and supply conditions.

• Sufficient instrumentation and adequate instrument redundancy should be considered to allow accurate readings of as many variables affecting the design as technically and economically possible. The data to be collected from the instruments should be sufficient to allow construction of accurate operating heat and material balances, and utility balances.

• Apart from analyzers located at key points in the process (for example, around the reactor, in the fluegas vents or product streams and so on), the design should include sample collection points at many different locations (and in the case of columns or separators, at different heights), to allow for gathering of additional information that was not originally considered during operations.

• Under some circumstances (if regulations allow it), given the temporary nature of pilot-plant operation and its R&D purpose, the project may have the opportunity to file for more expedited environmental and construction permitting, which can reduce development time in comparison with a conventional CPI project.

When procuring equipment and materials for the pilot, it is desirable that key components of the technology be custom-designed and built for the application (for example, if the technology involves an innovative contactor or internals design). Other non-technology-specific items could be sourced from standard commercially available items (typically more economical than custom-engineered items). If budget is a constraint, the team can also evaluate repurposing older (but still functional) pieces of equipment. There may be a risk that standard "off-the-shelf" or repurposed equipment may not be the best match or may have a lower-than-desired efficiency for the range of testing conditions. On the other hand, a larger number of non-standard, first-of-a-kind components also increases risk of failures or unpredictability of performance.

When preparing for operations, the R&D team should prepare a test plan that will enable them to acquire the data needed for scaleup and optimizations, aiming for the pilot plant. These tests should include variation of parameters that affect plant performance, collection and analysis of samples to verify product and byproduct compositions and quality, utility consumption per unit produced (including specific energy use), emissions per unit produced (now more relevant because of industry drive for decarbonization of processes), and any other parameters relevant to performance and cost estimation. Test duration may vary depending on the type of system, but typical ranges are 500–1,000 hours of continuous operation.

Testing documentation, aside from the collected data bank from instruments and analyses, should also consider operational parameters, such as unscheduled maintenance events, operational upsets, and any other deviations from expected operations and their workarounds. Any modifications made to the process while running the tests should also be documented in piping and instrumentation diagrams (P&IDs) and other applicable plant drawings. The test results report should have validated material and energy balances, utility balances and accurate performance metrics.

The results from the pilot test report should be used to update the techno-economic analysis and business case analysis for the technology. Accurate capital, operations and maintenance costs, and performance parameters obtained from the pilot-plant construction and operations should be used in conjunction with cost-escalation factors to improve pro-forma project financial statements for full-scale commercial projects.

The emissions, effluents, utility and energy consumption data should also

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be used to perform more accurate life-cycle analysis (LCA), especially if the technology is intended as a cleaner, more environmentally friendly alternative to an existing production process.

Full-size demonstration (7–9)

The next stage of technology maturation is to design, build and operate a full-scale demonstration system under the expected range of operating conditions. Given the larger size of the full-scale demonstration plant, development times and schedules will be similar to conventional large CPI projects (see Figure 1, for example), and will require applying for regular environmental and construction permits approval.

Learnings from the design and operation of the pilot plant will be used as reference for the full-size facility. The process flow diagrams, heat and material balances, P&IDs, equipment data sheets, specifications for piping, instruments and components can be used as basis, considering all markups or recommendations from the pilot-plant operations. Redundancy requirements (for example, pumps, compressors, and other vital equipment) can be higher for the demonstration plant, since it will be expected to operate continuously under commercial (or service) conditions.

When determining the scaleup strategy, a typical decision is to scale up by increasing capacity of the equipment, or by adding modules of similar capacity. Scaling up by increasing capacity usually comes with the benefit of economies of scale, but increases the risk that performance and cost will deviate from those predicted from the pilot-plant data. Also, very large pieces of equipment may require on-site assembly.

Scaling up by adding modules may come at the initial cost of dis-economies of scale, due to a higher number of smaller pieces of equipment, but may have several advantages that could prove beneficial in the long run: the smaller scaleup factor reduces the risk of unpredictability in cost and performance, the smaller module size may allow serial manufacturing at a factory (which benefits quality assurance and control), and the larger number of units may allow for learning curve effects to improve productivity (and reduce costs).

Often, a combination of both strategies is desirable. The team may select to design and build modules from a minimum commercially competitive capacity (as determined through technoeconomic and business case analysis) for the first-of-its-kind full-scale plant, and increase the module capacity over several future iterations of the technology, to access economies of scale while maintaining quality control of manufacturing. The initial modules can be designed to fit into units transportable by land or sea, and later modules that exceed transportation size limits could be separated into a series of packages (or "kits") that can be manufactured at the factory, then transported and sequentially assembled on site.

When evaluating the procurement and construction strategy for the first commercial plant, it is often recommended to begin considering long-term logistic solutions, including potential partnerships with suppliers of goods and services. At this point, the team may decide which parts of the supply chain to source from third-party suppliers, and which to source in-house.

Large engineering, procurement, and construction (EPC) firms that have well-established supply chains may elect to adhere to their existing processes and perform several design and assembly tasks in-house. Smaller or startup companies may opt for third-party engineering companies for design and workshops for module assembly tasks. When outsourcing design or assembly tasks, it is important to have adequate intellectual property agreements in place, as discussed below.

Performance testing for the demonstration plant should be similar to tests performed in similar projects in the CPI and should aim to validate fulfilment of desired performance targets. Performance curves, obtained from variation of flowrates and conditions (for example, start up, variation of load and so on) should be another important output of performance testing.

The cost and performance data

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collected in the performance tests should enable the team to make final updates to the techno-economic analysis and business case analysis, to improve their accuracy.

Risk-mitigation strategies

Each stage of technology development will have a different risk profile. For instance, low TRL stages will have higher technical and market risks, because the yields, efficiency and other performance parameters of the technology, and its fit with the market needs, are not yet understood; whereas higher TRL stages will have higher project-execution risks, since potential cost overruns, schedule delays, and health, safety and environmental risks associated with a large-scale project can bear a large impact on the organization.

Table 3 shows some typical risks faced at different TRL levels along with typical risk-reduction strategies that could be implemented.

Financing strategies. Technology development has inherent risks that make it unattractive to conventional infrastructure project-finance structures, given the lack of reference information to predict future cash flows (and debt repayment).

Large, established companies typically have an R&D budget to explore new technologies and may be able to fund the technology development using revenue from their ongoing operations. In their case, the R&D team should remain aware of internal resource allocation procedures and timelines, to provide sufficient information to secure internal approval and reserve funds for the next cycle (which varies from organization to organization, but frequently is organized so that project proposals are submitted some time in advance of the end of the fiscal year). The R&D team's proposal, depending on the size of the organization, may compete against other initiatives for resources, so it is important to ensure that the project is aligned with the organization's strategic direction and that it is structured considering the organization's financial situation.

Small businesses or startups, on the other hand, are typically limited by cash flow. For these organizations, the development plan should allow for significant investment of team time into fundraising activities. Different organizations offer alternatives for dilutive funding (cash contributions in exchange for a share of the company), ranging from incubators, angel investors, venture capital firms, and others. When searching for funding from these sources, the R&D team should have a clear assessment of the resources needed to achieve the next milestone in technology maturation and a clear plan to spend those resources. The R&D team should evaluate different potential investor groups, their strategy and stage at which they enter, and be aware that lower TRLs are associated with lower valuations of companies.

For large and small companies alike, there is the opportunity to apply for grants. Grants are a good source of non-dilutive funding and reduce

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financial risks of the project, by covering all or part of the investment required. Several agencies issue calls for proposals aimed at finding solutions for targeted problems, typically in line with public policies.

Grant applications are typically very competitive and require considerable time and effort to put together. When preparing a proposal, it is generally recommended to involve members of the team who are familiar with specific agency requirements and have a track record of submitting proposals and securing funding. Apart from the technical aspects inherent to the technology, the business aspects related to its competitiveness or marketability, and the managerial capabilities needed to successfully execute the project scope and meet the project objectives on budget and on schedule, the team working on the proposal should also address the political and stakeholder aspects of the project, with particular emphasis on how the success of the project will create benefits to the economy and the community. Participation of universities, small, disadvantaged businesses, or organizations from the community, though not necessarily required to fulfill the grant proposal requirements, is often positively viewed by evaluators.

When applying for grant funding, the R&D team should consider the schedule for the grant application, the resource requirements to deliver the pre-application and application documents in time, and the time from proposal preparation until award announcements and post-award negotiations (which could take several months). The R&D team should have a resource-allocation plan for staff that is not dependent on receiving grant funding at a specific date, to reduce risks.

Intellectual property management. Throughout the entire technology-maturation process, the R&D team will need to collect data, produce documents and engineering deliverables, exchange information with third parties (such as suppliers, partners, funding organizations or potential customers), so it is important to have a strategy in place to protect the intellectual property (IP) associated with the technology.

A data-management plan can serve as a basis to identify the types of information to be produced and how they will be managed. Project information should be maintained at a secure location with adequate information-security measures.

When communicating with third parties about the project, any material that could be published or shared should be reviewed to ensure that it does not contain sensitive information. If confidential information is to be shared, then non-disclosure agreements (NDAs) should be signed between the parties involved in the exchange, and the confidential information should be marked accordingly.

If third parties will be involved in the engineering, procurement and construction of the plant, or in other

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R&D activities, it is important to clearly establish, in writing, the ownership terms of the existing IP and any improvements that may arise from project development.

Any improvements over the state of the art that are deemed patentable should be kept secret until a patent application has been filed (in some jurisdictions, the inventor has a window of time to file a patent application from initial disclosure, but many jurisdictions do not allow it). The patent, once awarded, should be assigned in accordance with previous agreements regarding ownership of the IP.

License agreements, including provisions for royalty payments, should also be discussed and negotiated before the plant enters commercial operations, or before any specific party aside from the assignee wishes to offer the technology to potential customers.

Concluding remarks

First-of-a-kind CPI project development can be challenging and risky. It is crucial that the team responsible is familiar with the stages of technology maturation, the risks involved, and strategies to mitigate them. The steps of technology development should seek to minimize uncertainty in technical performance and costs, and the stage gates should aim to validate that the proposed technology can achieve target metrics before committing further resources. Several strategies can be utilized to minimize scaleup risks, and several funding options can be leveraged to share financial risks with entities that have considerably more resources and are willing to assume those risks if it can lead to a large market potential or positive societal impact. ■

Edited by Scott Jenkins

Acknowledgements

The authors would like to thank the individuals and organizations that have sponsored, hosted or contributed work to University of Illinois at Urbana-Champaign (UIUC)-coordinated projects, especially the U.S. Department of Energy and UIUC.

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Golden Rules of Electrical Temperature Measurement

Understand and follow these tips to ensure accurate and reliable temperature values

Dietmar Saecker
Endress+Hauser
Temperature + System Products

Even though electrical thermometers are used quite frequently in chemical process industries (CPI) plants, people often underestimate just how wrong the temperature displayed can be if these measurements are not planned carefully enough and new developments are not taken into account when selecting the right equipment. With some simple rules presented here, the accuracy of temperature measurement can be significantly improved without dramatically increasing the investment and maintenance costs.

Thermometers for the CPI

The task of a typical thermometer is to determine the temperature of the medium within a vessel or a tube and to convey this measured value to the outside. As robust designs must be selected in process technology, a modular design (Figure 1) has become established that also takes into account the requirements of maintenance staff.

The core of the thermometer is the measuring insert (M) — a standardized cylindrical component, the "hot" end of which has a temperature-sensitive sensor in it. On the "cold" side, the electrical wires are fed out of the tube or the mineral-insulated cable so that either a terminal block can be mounted or a temperature transmitter can be installed directly. The connection head (H) shields the electronics and the electrical connections against environmental influences. The extension tube (N) is used to ensure that the components within the connection head are far enough away from the process connection that they are generally protected from high or low temperatures during the process. The process connection (P) establishes the connection to the process. This generally includes threads, flanges or direct-welding connections. The area below the process connection is known as the thermowell or protective tube. This must be able to withstand the loads incurred with the process, that is, pressure, flow, chemical attack and, of course, the temperature of the medium. Thanks to this modular design, it remains possible to install or remove the measuring insert for calibration without having to open the process; that means medium cannot escape and nothing can enter the process from the outside (such as air or germs).

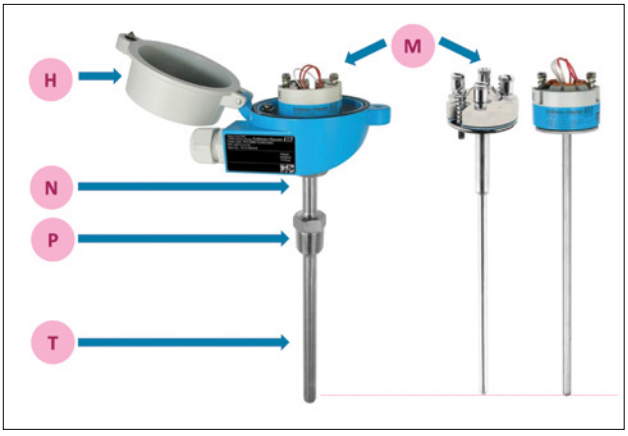

FIGURE 1. The major components of a typical electrical thermometer for process engineering is shown here (M = measuring insert; H = connection head; N = extension tube; P = process connection; T = thermowell)

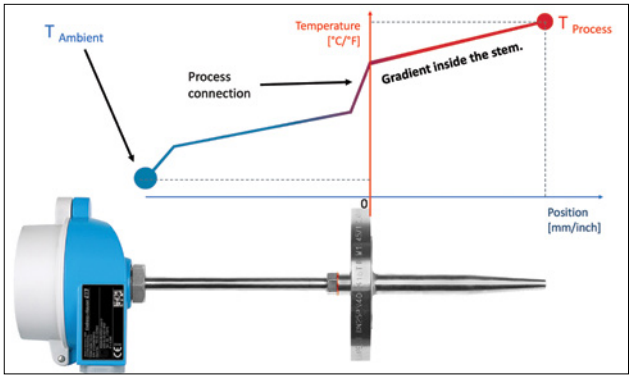

FIGURE 2. Shown here is a simplified temperature gradient along the length of the device for the case when the process temperature is greater than ambient

IN BRIEF

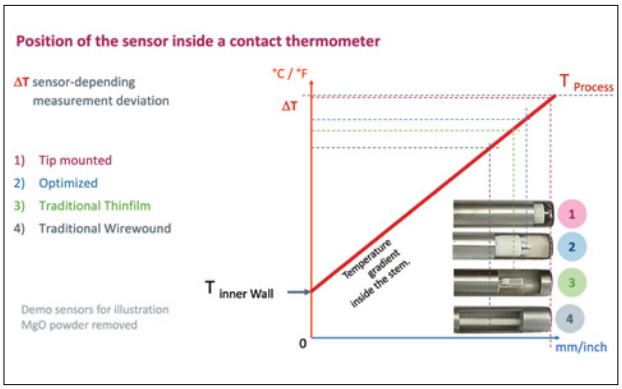

FIGURE 3. The temperature gradient inside the stem of the device is influenced by the size and location of the sensor

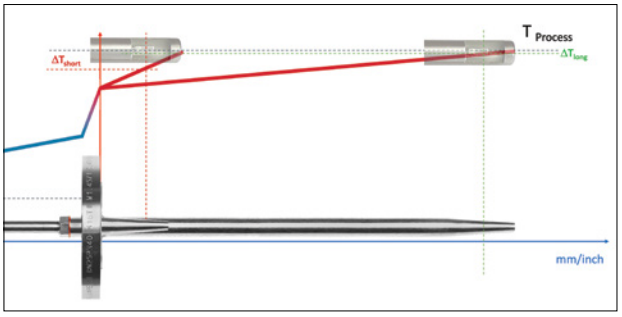

FIGURE 4. The length of the thermometer installation can have a big influence on the measured temperature value

Energy flow in the thermometer

An industrial process thermometer made from stainless steel also establishes a metallic energy connection between the temperature of the media and the ambient temperature. As with an electrical circuit, energy flows via the heat conductor if there is a difference in temperature. The voltage decreases across a resistance and the temperature changes along the thermometer. This also leads to a temperature gradient between the inside and the outside within the thermometer structure itself. In an simplified representation, this temperature curve can be presented by a series of straight lines. Its gradient in relation to the position in the thermometer depends on the thermal conductivity of the material mix and on the ability to conduct heat via convection to the environment. Large flanges or screw connections therefore lead to a steeper profile since more energy flows out.

However, when assessing the measuring accuracy, it is the temperature curve within the process that is particularly relevant, that is, the area where the thermowell is immersed in the medium. Figure 2 shows that the temperature in the thermometer increases from the starting level at the process connection towards the tip of the thermowell.

(Note: The example in this article describes the case in which the process medium is hotter than the ambient temperature, that is, heat energy is withdrawn from the process and transferred to the environment. In the case of cold media, energy flows from the outside into the process. All the rules apply here as well, but with the signs inverted: all installation-related errors in cryogenic applications are "positive" instead.)

The most important rule for any contact thermometer, however, is the following: **Every contact thermometer can only show the temperature that its physical sensor itself experiences.**

For any further analysis, it is important to consider where in the thermometer this sensor, such as a Pt100 measuring resistor, is actually installed, but also the size of this sensor is relevant because the temperature along its position may not be constant.

Figure 3 therefore shows the cross sections of various measuring inserts on which the surrounding powder or casting material has been removed. The designs vary depending on the choice of sensor and its position inside the measuring insert.

Sensor position

If we graphically transfer the distance from the tip to the expected temperature gradients, a direct qualitative connection can be read off between the installation position and the measurement result. The further the measuring position is away from the tip, the larger the deviation from the actual process temperature. In the application shown in Figure 2 — a process that is hotter than the environment — this installation error is always negative, that is, the process is in reality hotter than the value displayed.

With a traditional design with a wirewound resistor (No. 4 in Figure 3), a temperature-sensitive area is created, which starts approximately 5 mm from the inner wall of the measuring insert and ends at approximately 20 mm. The display therefore shows the average temperature in this area. According to the simple model in Figures 1 and 2, this therefore corresponds to the temperature at approximately 12 mm from the tip.

A thin-film measuring resistor is much smaller, whereby the averaging effect only relates to a smaller area. In its traditional design (No. 3 in Figure 3), a sensitive area is created at a distance of between 7 and 10 mm.

In an optimized design, which can also be used if there are very high vibrations, a special manufacturing process is used to encapsulate the sensor in a type of concrete nearer to the tip (No. 2 in Figure 3). The area to be measured is therefore around 5 to 6 mm in front of the tip.

With a tip-sensitive measuring insert (No. 1 in Figure 3), it is possible to secure the sensor directly to the metal inner wall of the measuring insert. Furthermore, the Pt100 has been rotated by an angle of 90 deg so that it lies flat on the tip. In fact, the temperature-sensitive area is only approximately 1 mm away from the outer side of the measuring insert.

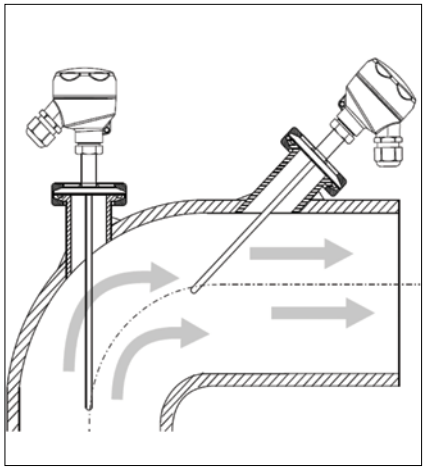

FIGURE 5. For small-diameter pipes, it is recommended to install the thermometer in an elbow against the direction of flow, to avoid potential problems from vibrations

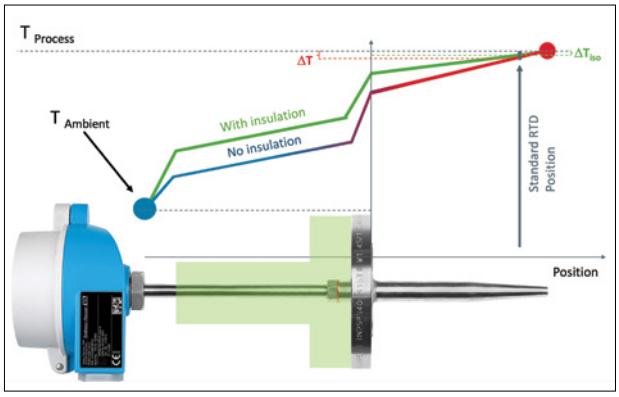

FIGURE 6. External insulation not only improves the energy efficiency of the process, but also improves the accuracy of the temperature-measurement equipment

A very small, almost negligible error only arises if using the tip-sensitive measuring insert. However, this can only be used at temperatures up to 200°C. Since the error to be expected becomes greater when the temperature difference between the inside and outside increases, it is important to ensure the correct installation of the thermometer, especially at high temperatures.

Notes on installation

The temperature of the process connection depends in particular on how much energy is emitted from its outer side to the environment. The result is a specific temperature level that effectively represents a starting point for the residual gradients up to the process temperature. By extending the thermometer installation depth, the temperature gradient in the thermometer therefore levels off. At the position where the sensor has been installed, it is warmer with a flat gradient, which means that the accuracy of the measurement increases with the installation length.

If the thermometer is installed perpendicular to the tube, the opposite tube wall is the limit for the installation length. The solution is to install it at a flatter angle or to install it in a tube elbow, as shown in Figure 5, whereby the counterflow direction should be the preferred choice.

However, a limiting factor for the length of the protective tube is its increasing tendency to vibrate the longer it is. Due to the longer lever and lower resonance frequency of the design, there is an increased risk that the thermometer will be bent by the flow, or will be made to vibrate so strongly that it can break due to fatigue. The maximum permissible length should therefore be determined by a protective tube calculation, in accordance with ASME or DIN guidelines [*1, 2*].

External insulation

Adding external insulation to the extension tube has a similar effect as extending the installation length, but it can also be applied retrospectively.

Thermal insulation on the outer surfaces of the thermometer increases the temperature level of these areas (Figure 6). Starting from the hotter process connection, the residual temperature gradient between the inside of the process connection and the thermowell tip is flatter than would be the case

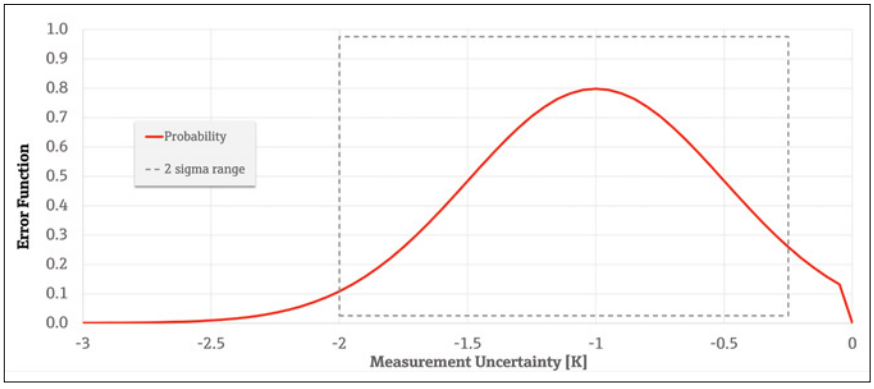

FIGURE 7. This unsymmetrical distribution shows the typical measurement uncertainty distribution of installation errors ($\mu = -1K$; $\sigma = 0.5K$)

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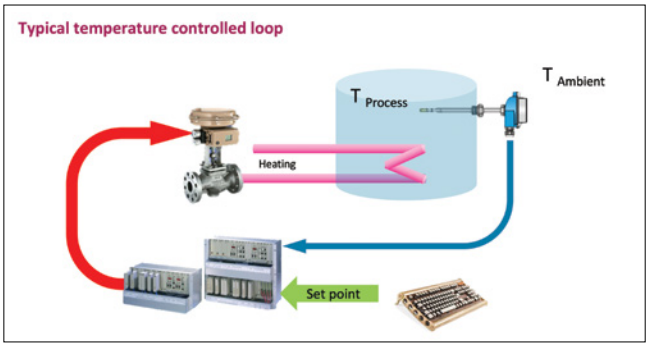

FIGURE 8. Most temperature-measuring points are embedded in closed-loop systems, as shown here

without thermal insulation. This also increases the temperature at the position of the sensor (that is displayed). Insulation on the outside thus not only improves the energy efficiency of the process, it also improves the accuracy of the temperature-measurement equipment on the inside.

Quantifying heat-transfer errors

The size of the error caused by incorrect installation depends in particular on the temperature difference between the process and the environment. It may be up to –5% of this difference.

This means that these installation errors may have a much greater influence on the overall accuracy than either the class accuracy of the measuring insert or the measurement uncertainty of the temperature transmitter. In any further measurement-uncertainty calculation, it must be taken into account, that the error cannot be positive since the sensor cannot be at a higher energy level than the process itself. Figure 7 shows an example of a non-symmetrical distribution function.

Impact on closed loops

The majority of all temperature measuring points are embedded in loop systems (Figure 8).

In closed-loop systems, negative temperature-measuring errors can be dangerous. Since the controller does not know about the installation errors, it interprets the measured value as being too low. As a result, the energy supply is increased until the expected target value is displayed. At the end, the actual temperature in the process is thus higher than displayed by the amount of the measuring error. This can impact the quality of the product and the safety of the system. This error will most definitely negatively impact the energy balance of the process.

Final remarks

Thermometer installation errors at temperature-measuring points can be prevented. In hot processes, heat-transfer errors are generally negative, in cryogenic media, temperatures are displayed that are too high. Sufficiently long installation lengths should therefore be planned and calculated from a safety perspective as early as the system-planning stage. External insulation will improve measuring performance and energy efficiency. By selecting the appropriate measuring insert (sensor design) for the installation situation and temperature measuring range, in which the sensor is installed as far forward as possible, the accuracy of the measurement can also be improved retrospectively. ■

Edited by Gerald Ondrey

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Acknowledgments

All figures are courtesy of Endress+Hauser.

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Promoting Safety on the Job: An Approach for Today

By providing comprehensive ongoing training solutions, promoting emergency preparedness and implementing proactive safety guidelines on a day-to-day basis, employers can set their staff up for success

Clare Epstein
Vector Solutions

In 2023, the Occupational Safety and Health Administration (OSHA; Washington, D.C.; www.osha.gov) reported a total of 29,747 workplace violations — a nearly 35% increase from the year before [*1*]. This should be a major cause for concern among employers in the chemical process industries (CPI), as violations like insufficient fall protections and hazard communications can lead to employee injury — and even fatalities in some cases (Figure 1).

While OSHA's full analysis of workplace safety in 2023 has yet to be released, what we do know is there were 5,486 fatal work injuries in 2022 [*2*]. This was a marginal increase (5.7%) from 2021, but any uptick in workplace fatalities — no matter how seemingly minor on paper — means an uptick in families and friends mourning the often preventable loss of a loved one.

With OSHA violations and workplace injuries on a steady incline, chemical manufacturing employers have an urgent responsibility to ensure that their workers are properly trained and adequately prepared for the hazards they may encounter on the job. This can be accomplished via the implementation of comprehensive, up-to-date and ongoing safety training.

This article explores the role of training and preparedness, how these practices are poised to prevent the most common OSHA violations and the tools and tactics employers have at their disposal to keep their workers confident and protected.

Dynamic, ongoing training

Knowledge is an employee's greatest asset when it comes to avoiding hazards and navigating emergencies on the job. However, standards and regulations are constantly changing, as are the risks an organization might face. Chemical manufacturing employees in particular face specific risks — namely, chemical spills, leaks and releases that can severely impact both individual staff members and the public at large. Everything from changing climate conditions to fluctuating employee headcounts to opening a new facility has the potential to introduce new risks to employees. Multipronged and ongoing safety training is therefore imperative.

But it is critical to note that safety training should never be static and is a required element of OSHA's Process Safety Management (PSM) standard [*3*]. Workers need access to the latest information so they can implement new technologies and remain compliant with emergent regulations. OSHA's PSM standard requires the proactive identification, evaluation, mitigation or prevention of highly hazardous chemical releases. Chemical engineers need to be focused on any additional modifications and updates to the PSM standards, as well as continued compliance with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) [*4*]. For more information on the GHS, see The Globally Harmonized System, *Chem. Eng.*, December 2013, pp. 42–44.

Learning-management technology can provide platforms that offer a wide variety of online training options, including interactive education geared specifically to the needs of the CPI. For example, employers looking to train their chemical engineers and chemical processing employees on the GHS standard, PSM, industrial maintenance and skills, or instrumentation and controls can offer valuable content through a digital learning-management platform.

In addition to training workers during the onboarding process, organizations must offer ongoing and refresher training so that staff can refamiliarize themselves with important concepts and procedures as necessary. Otherwise, they run the risk of forgetting vital information, which could lead to negligent onsite behavior.

FIGURE 1. Diligent fall protection and hazard communication are crucial to avoid workplace safety incidents and non-compliance

Emergency preparedness

OSHA requires all employers to develop, implement and train all employees on an Emergency Action Plan (EAP) [*5*]. Organizations that manufacture, process and utilize chemicals must ensure that their EAP includes scenarios for handling chemical releases. This is another area where ongoing education is required — OSHA mandates that employees be trained on the EAP upon hiring and when their responsibilities under the plan change due to promotion or transfer. Most employers choose to train their staff on an annual basis to keep the EAP fresh and top-of-mind. The following are a few tips for employers to strengthen their emergency preparedness posture.

Provide leaders with emergency training. OSHA requires employers to designate and train emergency evacuation leaders. These individuals need to be trained on communication procedures, evacuation routes and their facility's emergency alarm

TABLE 1. SELECTED STANDARDS RELATED TO FREQUENT OSHA VIOLATIONS	
Issue	**OSHA Standards (general industry and construction)**
Fall protection	1910.140; 1926.501–503, 1926.760; 1926.1423
Hazard communication	1910.1200; 1910.1201; 1926.59
Ladders	1910.23; 1926.1051; 1926.1053; 1926.1060
Scaffolding	1910.27; 1926.451; 1926.452; 1926.454
Powered industrial trucks	1910.178
Lockout/tagout	1910.147
Respiratory protection	1910.134; 1926.103
PPE and lifesaving equipment	1910.132
Machine guarding	1910.211–1910.219; 1910.262–263; 1926.300–306

systems to confirm they are able to coordinate an employee evacuation when necessary. Education on soft skills is also incredibly important. Leaders should be educated on topics like stress management, interpersonal leadership skills and diversity, equity and inclusion. This will make navigating an emergency as seamless as possible.

Train employees on multiple scenarios. There is a vast array of emergency scenarios for which modern workers need to be prepared. Fires, extreme weather conditions, active shooter and workplace violence, chemical spills and cybersecurity attacks all fall under this umbrella. Employers must identify which of these scenarios are the most relevant to their organization (for example, a facility in Kansas may benefit more from a tornado-based EAP than a hurricane-based one) and train every level of the business on the proper procedures to follow should such a scenario occur.

Leverage technology to supplement preparedness training. Digital e-learning tools are a cost-effective and efficient option for organizations looking to train a large number of employees on a broad range of emergency scenarios. Interactive modules walk the staff member through a hypothetical emergency, enabling them to witness different outcomes based on the choices they make. Such platforms may also offer 3-D modeling so that employees can visualize the impacts of hazards like fires or floods on their facility.

Avoid frequently cited standards

The safety of workers should always be employers' top priority, especially in particularly hazardous environments. But improper practices are not just a safety risk; they have financial implications, too. Notably, the price of negligence is only increasing — the maximum penalties for serious and other-than-serious violations increased from $14,502 to $15,625 in 2023 [6]. What's more, the maximum penalty for willful or repeated violations has now reached $156,259 per violation.

As such, employers need to be keenly aware of how to prevent violations from occurring. The following sections outline how proper training can help prevent the top ten most frequently cited OSHA violations of 2023. See Table 1 for associated relevant OSHA standards.

1. Fall-protection general requirements. Employees need to be familiarized with the correct use of equipment, how to conduct inspections, and helpful techniques to minimize the risk of falling.

2. Hazard communication. Workers must know how to identify hazardous chemicals, substances and materials. Understanding what substances are present in their workplace and knowing exactly how to respond when a potentially hazardous material spills or is mishandled will keep them informed of and ready to tackle potential risks.

3. Ladders. Employees must be trained on best practices for using, storing and maintaining ladders in the workplace.

4. Scaffolding. The right training will educate workers on the various scaffolding types they will be dealing with, as well as proper assembly procedures and the potential dangers associated with scaffolding. Safety measures for erecting, inspecting and dismantling scaffolding must be strictly adhered to.

5. Powered industrial trucks. Keep employees apprised of forklifts' common safety features and working dimensions and ensure they understand the correct procedures for operating these vehicles.

6. Lockout/tagout (LOTO). Dangerous machines must be completely shut off during maintenance or servicing work. Employees need to know the specific measures required to shut down these machines so they can perform maintenance without risk of injury.

7. Respiratory protection. Employees must be familiar with the different types of respirators available and when and how to use them.

8. Fall-protection training requirements. The right training solution will enable workers to walk through interactive scenarios involving fall hazards. Such tools will guide them through choosing the right fall-protection equipment and techniques while still covering related legal standards.

9. Personal protective and lifesaving equipment (PPE). In addition to respiratory protection, employees need to be familiar with the correct selection, fitting and usage of PPE for the protection of their face and eyes. Comprehensive training solutions will provide examples of incidents where proper PPE usage prevented workers from getting injured on the job to illustrate its importance and encourage compliance (Figure 2).

10. Machine guarding. To ensure physical barriers and safety devices are adequately preventing hazardous machine components from injuring workers, employers should implement training solutions that provide tools, such as interactive checklists for inspecting and maintaining their machine guards.

Clear and apparent SOPs

In addition to implementing the right training solution, employers can prioritize employee safety by

FIGURE 2. Employees should not only be trained in PPE best practices, but should also be empowered to help other employees ensure they are wearing their PPE properly

establishing and training on standard operating procedures (SOPs). Transparent communication between employees, their peers and their supervisors is a surefire way to keep everyone on top of potential risks. If an employee becomes aware of a potential hazard, like a chemical spill, they need to know exactly who to inform and how to do so.

Employers must also establish standards and provide appropriate training for employees on the proper usage of PPE. OSHA has a number of requirements surrounding the usage of PPE [*7*]. Employers must make these requirements crystal clear to their staff and encourage workers to speak up when equipment is damaged, missing or if they notice a peer wearing their PPE incorrectly.

If employees or contractors work directly with hazardous materials, like most chemical manufacturers, employers need instructions in place to control and manage those materials. Procedures and standards on cleaning and maintaining work-area mats, using separate cleaning tools for various spills to prevent cross-contamination, and changing out of clothes that have been exposed to toxic materials, are required. These practices will both keep employees safe from hazardous materials at work and minimize the risk of exposing others once they leave the facility.

Beyond these standards, there are a number of additional efforts employers must make to prioritize day-to-day safety. Keeping pathways to work areas and emergency exits clear and identifying and removing fire hazards are just a few examples of further precautions mandated by OSHA.

A safety-first culture

Prioritizing employee safety has a number of positive implications for your organization. The most obvious of these is that with the proper training solutions and guidelines in place, workers are less likely to become injured while completing their daily tasks.

Proper training can also support retention efforts. According to the American Chemistry Council (ACC; Washington, D.C.; www.americanchemistry.com), employment in the chemical industry surged in 2022 but is expected to fall from this high [*8*]. Giving employees the tools they need to safely do their jobs will nurture confidence in their abilities and trust in you as an employer. When workers feel holistically supported by their organization, they are less likely to seek out other opportunities. By following such rigorous training and preparedness strategies, employers can set their staff up for success in any scenario. ■

Edited by Mary Page Bailey

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Transforming Chemical Supply Chains with Digital Product Passports

Accurately tracking and tracing data across the supply chain can help manufacturers and consumers alike understand the sustainability of products and processes

Juan Miguel Perez
Finboot Ltd.

The chemical process industries (CPI) face increasing pressure across the globe to operate sustainably at every level of the supply chain, from upstream petrochemical producers to downstream industrial and domestic chemical manufacturers. Customers, regulators, employees, communities near production plants and investors are all demanding that manufacturing firms accelerate their journey to net-zero carbon emissions and shift to more sustainable models and, crucially, that these groups can demonstrate this with verifiable and reliable data.

This is the challenge of the age, a challenge further aggravated by the climate emergency. The CPI must invest to shift to a more sustainable way of producing the vital chemicals society needs. But this alone will not be enough — in a global business landscape where "greenwashing" is rife, the manufacturing companies need proof points to demonstrate the shift to sustainability. Firms need to find ways to collect, verify and share reliable and immutable data. They also must find new and improved methods for recordkeeping and accountability. This new recordkeeping needs to be scalable to be applicable at industrial levels and not merely used in pilot programs.

As CPI companies increase their use of renewable feedstocks, these processes become more complex than the old processes that used fossil fuels.

Finboot Ltd. (Barcelona, Spain; www.finboot.com) is working with leading industry players to provide solutions related to the lack of immutable, verifiable and trusted data to provide evidence of the circularity in the supply chain.

Finboot's blockchain-powered solution, MARCO Track & Trace, can create digital product passports (DPP; Figure 1) that provide process engineers, managers, regulators and consumers alike with information about a product's origin, production process and sustainability credentials, helping them make informed choices. From raw-material suppliers, manufacturers and distributors to retailers, each step of the supply chain can be tracked and traced digitally. In addition, this transparency helps identify any inefficiencies, high-carbon-emission "pinch points," delays and other issues in the production process.

Industry example

Finboot has been working with Cepsa Química S.A. (Madrid, Spain; chemicals.cepsa.com) — a global energy company with a diverse portfolio spanning oil-and-gas and petrochemicals — since the start of 2023. Cepsa's homecare industry portfolio is the world's largest producer of linear alkylbenzene (LAB), a key material used in the production of detergents. Cepsa Química has developed NextLab, a LAB product produced from renewable raw materials, including crude palm-kernel oil and coconut oil. This, in turn, enables production of sustainable and biodegradable detergents.

Palm and coconut oils are versatile vegetable oils, but they are also contentious raw materials often linked to deforestation and unethical farming. As such, Cepsa wanted to instill traceability throughout its supply chain and track the raw materials' journey from sustainable plantations to bio-refineries and, eventually, to their production facility for ethically sourced sustainable chemicals.

The continuous nature of Cepsa's production process requires maintaining a mass-balance record for all sustainable products. As production scales up, the data-management requirements increase in complexity, particularly because production facilities are not exclusively set up for more circular chemical production. Currently, NextLab is often blended with fossil-fuel-derived LAB.

Finboot's MARCO Track & Trace platform has allowed Cepsa to implement digital traceability systems for tracking each batch of vegetable oil from its origin to its use in biodegradable surfactant production, in addition to automating book-keeping tasks and determining what percentage of output is from renewable and circular inputs.

Cepsa currently has three NextLab plants located in Brazil, Canada and Spain. All three plants trace production using Finboot's digital product passport, providing a quick snapshot of the entire supply chain of that product, and all requisite certificates of analysis. Because MARCO is fully configurable, the version used is bespoke to Cepsa, including multilingual functionality — in Cepsa's case, using Portuguese, French and Spanish.

As David Liras, director of Cepsa Chemicals explains: "We partnered with Finboot because it is an experienced and innovative company in its sector. Finboot's product enabled us to rapidly implement a digital traceability ecosystem powered by blockchain technology, which ensures that every step of our supply chain is securely recorded, enhancing our credibility and accountability. This innovation will help us to maintain our clients' trust in our renewable chemicals."

Preparing for the future now

Cepsa's experience demonstrates the advantages for companies

FIGURE 1. Digital track-and-trace platforms can help to verify product and raw-material sustainability across the full supply chain

in the chemical industry in using blockchain-based digital product passports to address current industry-wide challenges.

The first clear advantage to using a digital product passport is the significant operational efficiency it provides when gathering data at large scale over the course of complex production processes. Keeping track of such complex data trails in a spreadsheet is no longer sufficiently robust to satisfy stakeholders. Any company genuinely committed to scaling up sustainable solutions needs to back up their claims with accurate record-keeping.

The second advantage is that customers are subject to the same increasing pressure and ethical concerns from stakeholders as suppliers, and are similarly calling for transparency and supply-chain visibility in a more granular format. By utilizing digital product passports, companies like Cepsa gain this possibility in an accessible solution, improving customer satisfaction.

In an industry that has historically struggled to maintain a positive image in the face of accusations of pollution and environmental harm, for large manufacturing organizations, there is a great deal of value to be gained from protecting its reputation by enhancing visibility over their supply chain and backing up its sustainable credentials with hard evidence.

Finally, and perhaps most critically, Cepsa is now well ahead of the anticipated E.U. regulation resulting from the European Commission's amended Ecodesign Directive, which will require fully traceable accounting for products, as provided in Finboot's Digital Product Passports, and impose new duties and rights across most industries, including chemical manufacturers. This legislation is expected to come into effect beginning in 2026, and there is a clear commercial imperative for leading CPI players to get ahead of the curve.

As the chemical industry is now operating in an era of heightened environmental awareness, scrutiny and accountability, Digital Product Passports are not just a "nice to have" option but are rather a "must have" benefit for survival and growth. digital product passports enhance operational transparency, meet customer and stakeholder expectations, enhance reputational integrity and ensure regulatory compliance. Ignoring them until forced to comply will result in competitive disadvantage and diminished stakeholder trust. ■

Edited by Mary Page Bailey

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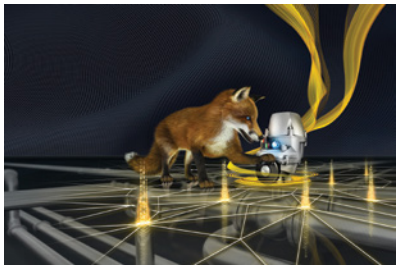


AUMA Riester

EnviroFALK

ACHEMA2024
Frankfurt/Main
10–14 June 2024

Fluidized-bed technology for small-scale development work

In addition to its pelleting technology, this company will also showcase its extensive expertise in fluidized-bed technology. Among the equipment being exhibited are the flat-die pellet mills type 14-175 and 33-600, as well as the LFB Batch mini L (photo) fluidized-bed plant. The LFB mini is a compact plant for laboratory applications, and has features to perform fluidized-bed processes, such as drying, agglomeration, spray granulation, microencapsulation or coating of powders, granules or pellets in small batch scale for product quantities from 200 to 2,500 g. The LFB mini consists of a compact stainless-steel housing with integrated control system and air technology (filter, air heater and fan). — Hall 6.1, Stand B47 — *Amandus Kahl GmbH & Co. KG, Reinbek, Germany*
www.akahl.com

Dewatering and drying solutions for solid-liquid separation

One highlight being exhibited is the Krauss-Maffei dynamic crossflow filter DCF (photo) — a technology that has proven itself suitable for the clarification of liquids and for concentrating and washing of solids for a broad variety of chemical and pharmaceutical products, such as the solid-liquid separation step in the production of diabetes-care products. The technology is highly reliable, because the open filtration area avoids any blockages, thereby eliminating the need for manual intervention. The filters work in a way that is completely enclosed and fully automatic, including the cleaning-in-place (CIP) and sterilization-in-place (SIP) features. Hall 5.0, Stand B4 — *Andritz AG, Graz, Austria*
www.andritz.com

A smart actuator now available as an explosion-proof version

This company is highlighting its small, smart, ProFox actuator series (photo), which recently has been expanded with a new explosion-proof version — ProFox-X. ProFox-X actuators have ATEX and IECEx certifications for the highest gas group, IIC T4, and ensure safe operation in potentially explosive atmospheres, including hydrogen applications. Both ProFox and ProFox-X actuators support fieldbus and Industrial Ethernet communication, making host-system integration flexible and easy. The actuators' embedded data logging is a perfect match for Coralink, this company's digital ecosystem, enabling advanced diagnostics and predictive maintenance. Motor speed is adjustable, ensuring fast and precise positioning. Soft-start and soft-stop functionalities increase valve lifetime. Hall 8, Stand C23 — *AUMA Riester GmbH & Co. KG, Müllheim, Germany*
www.auma.com

Water-treatment technology for supplying electrolysis plants

"Green" hydrogen is produced by electrolysis, a process that requires ultrapure water. Ultrapure water is treated in several process stages. An important process for maintaining consistently high-quality water is recirculation purification (photo). In the so-called refinement loop, the water is repeatedly purified by a polishing system. Circulation purification is either integrated directly into the feed-water-treatment system or is added as a stand-alone unit to an existing process water-treatment system. The feed-water treatment, as well as the circulation purification, can be modularly constructed for individual system integration into the overall electrolysis concept. Water sources such as sea, river, surface or waste water, can be used for feed-water treatment. Hall 4.1, Stand D49 — *EnviroFALK GmbH, Westerburg, Germany*
www.envirofalk.com

A whole range of new filtration products for liquids

This company is exhibiting numerous new filtration products, including the new Sentinel Maxpo and Duragaf MaxpoXL specialty filter bag ranges, the new simplex and duplex pipeline basket strainers, the new Becon Carbon ACF03 activated-carbon depth-filter sheets and the new printing set for the CCS 5 contamination-control system. For example, the new Becon Carbon ACF 03 grade is available in flat-sheet, stacked-disc cartridge (photo) and disposable-capsule designs. These designs were developed to meet the growing demand for user-friendly activated-carbon sheets tested for endotoxins for pharmaceutical, biopharmaceutical and fine-chemical applications. The activated carbon depth-filter sheets can be used in Beco Integra Plate enclosed plate-and-frame filters, for which the company is launching a new cleaning solution. Hall 5.0, Stand C15 — *Eaton Technologies GmbH Filtration Division, Nettersheim, Germany*
www.eaton.com/filtration

More efficient processes with Ethernet APL

Digitalization not only contributes to greater sustainability, but also promotes increased efficiency. This requires intelligent, seamlessly networked measurement technology. The networking of field devices offers great potential for improving system performance. However, 97% of field data have so far remained unused, according to this company. Thanks to Ethernet Advanced Physical Layer (APL; photo), it is now possible for devices in the process industry to communicate with each other at high speed and over a distance of up to 1,000 m. This company will show that Ethernet APL is a key technology that closes the gap in the automation pyramid towards the field level, and thus opens doors for more efficient processes, the company says. Hall 11.1, Stand C27 — *Endress + Hauser, Reinach, Switzerland*
www.endress.com

Active infrastructure for Ethernet APL

Ethernet APL enables a network infrastructure for seamless access from hazardous areas to the control or board room — providing insights into production quality and status. Via the Ethernet-APL field switch from FieldConnex (photo), multiple applications can simultaneously query information from the field. An extra layer of diagnostics about the physical layer itself enables personnel to detect and eliminate errors or creeping quality degradation in the installation. Diagnostics with Ethernet-APL technology assist users in maintaining production quality and uptime. The switch reports

Eaton Technologies, Filtration Division

Endress + Hauser

Pepperl+Fuchs

Hosokawa Alpine

physical layer measurements, even for fiber-optic transmission. Specially designed small form-factor pluggable (SFP) modules connect the switch to the network via single-mode and multimode fiber-optic cables, supporting cable lengths of up to 30 km. They are certified as an accessory to the switch for installation in Zone 2/Div. 2. Hall 11.1, Stand A43 — *Pepperl+Fuchs SE, Mannheim, Germany*
www.pepperl-fuchs.com

Fette Compacting

Ultrafine grinding of coarse materials without pre-crushing

In contrast to traditional spiral jet mills, the large, central inlet of the Alpine Microburst (AMB) spiral jet mill (photo) allows more coarsely ground products to be processed directly. Up to now, this required pre-crushing. Even fibrous products, which previously could only be crushed with great effort or hardly at all, can now be finely milled with the AMB. The mill offers benefits for the manufacture of functional foods or finely ground food products, for example. Use of the new AMB spiral jet mill lends itself perfectly to the trend towards "all natural" products, where natural flavors and colors are used in the final products. The spiral jet mill also opens up completely new possibilities for processors of cannabis, fibrous products, cellulose or biopolymers. Hall 4.1, Stand F37 — *Hosokawa Alpine AG, Augsburg, Germany*
www.hosokawa-alpine.com

Heinkel Process Technology

A new, continuous way to produce tablets

The FE CPS continuous system (photo) is industry's new state-of-the-art solution for continuous dosing and blending of raw materials, including conveying and delivering the high-quality blend to any downstream powder-processing equipment. When combined with a tablet press, the result is a Continuous Direct Compression line. For tablet production, the powder is fed from the FE CPS into the tablet press without additional granulation. Compared to granulation-based production, several steps are eliminated, which reduces space requirements and energy consumption and makes the process leaner overall. The system is capable of processing a wide range of ingredients in a variable throughput range of 5 to 200 kg/h. It can dose and mix up to six powdered raw materials and transfer them to the downstream process. The system unit, together with the tablet press and terminal, can be installed on a single level, facilitating its integration into existing production environments. Hall 3.0, Stand F3 — *Fette Compacting GmbH, Schwarzenbek, Germany*
www.fette-compacting.com

Phoenix Contact Deutschland

A new peeler centrifuge with patented features

With the new Bluetector peeler centrifuge (photo), energy savings of approximately 50,000 kWh/yr can be realized due to the innovative drive concepts — even in hazardous areas up to ATEX zone 1. The elimination of hydraulic oil and drive belts result in optimized cleanliness and ease of maintenance. A slidable machine cover protects the technical areas of the machine, facilitates maintenance work, reduces noise emissions and ensures a safe working environment for the machine operator. The new peeler centrifuge ensures low-shear and gentle product discharge, offering maximum flexibility for the discharge process, as the parameters can be variably adjusted. Hall 6.0, Stand C49 — *Heinkel Process Technology GmbH, Besigheim, Germany*
www.heinkel.de

Solutions for a sustainable process industry

Data transmission in the process industry is an elementary factor when it comes to the integration of digital fieldbuses. Against the background of complete digital communication right down to the field level, this company's new Ethernet APL switch (photo) enables the direct two-wire Ethernet connection of APL field devices in the Ex zones. This means that not only the process data, but also other valuable device information straight from the field level, can be used. This is presented on an APL multi-vendor panel. Other demonstrators will be presenting monitoring and surveillance solutions that enable predictive maintenance based on NAMUR Open

Architecture (NOA). Hall 11.1, Stand A31 — *Phoenix Contact Deutschland GmbH, Blomberg, Germany*
www.phoenixcontact.de

A new machine for optimized IR-welded pipe connections

The IR-63 M (photo) is a new infrared (IR) welding machine that maintains established technology while integrating new hardware and software features for faster, more convenient and more efficient welding. Thanks to a machine-controlled process, IR fusion machines ensure contact-free and high-quality welds in sectors such as chemical processing, microelectronics or water treatment. With the IR-63 M, this company aimed to further simplify and expedite the welding process for materials such as PVDF, ECTFE, PP-H, PP-n, PE, or PVC-U. The updates have resulted in 20% shorter preparation times, 30% fewer installation steps and 50% shorter cooling times, says the company. An integrated Connectivity Box facilitates access to the company's cloud service. Hall 8.0, Stand E64 — *Georg Fischer GmbH Piping Systems, Albershausen, Germany*
www.gfps.com

Unlock process-control potential with process refractometers

The Polaris (photo) is this company's latest-generation process refractometer platform, which is designed to optimize users' processes, conserve resources, save energy and enhance productivity and product quality. These process refractometers are used for inline liquid-concentration measurements for various industries, installation positions and applications. The real-time measurement data they produce from the process enable advanced and accurate process control, enhancing the manufacturing process. The process refractometer can measure various liquid concentrations through refractive index — inline and in real time. Hall 11.1 Stand C76 — *Vaisala, Helsinki, Finland*
www.vaisala.com

Collaboration yields a new generation gear pump

The acquisition of Witte by this company at the beginning of 2023 marks the start of a new path of cooperation. The two companies have merged to create a new generation of gear pumps — the Chem-X (photo). The new product can be set with an intelligent control system. These systems allow the pump to adapt to changing operating conditions, improving performance and reducing mechanical wear. Additionally, remote monitoring capabilities and predictive diagnostics enable proactive maintenance, minimizing downtime and operating costs. The pump features an advanced gear-tooth design, optimized for minimal hydraulic pulsation and maximum volumetric efficiency. The use of innovative materials ensures that the pump can withstand harsh chemicals and high temperatures without compromising its lifespan or performance. — Hall 8.0, Stand K78 — *Maag Group, Oberglatt, Switzerland*
www.maag.com

Produce very thin films with this casting system

This company has developed a continuous film-casting system incorporating a Venturi drying module (photo) for the production of very thin films to fine tolerances. A slot die applies the liquid product directly onto a polished stainless-steel belt, which then passes through controlled drying segments where the solvent in the liquid is evaporated. As well as dry film casting to 10–300 µm, the system can also be used to produce high-quality microporous membranes. Applications include the production of separator membranes and ceramic tapes used in lithium-ion batteries, fuel cells and solid-state batteries. Hall 4.0, Stand C24 — *IPCO Germany GmbH, Fellbach, Germany*
www.ipco.com

This laboratory mixer does more than just mixing

Thanks to its multifunctional capabilities, the Cleanline C5 mixer (photo, p. 46) is able to replace multiple previous machines. The processor performs a range of process steps — such as mixing, granulating, coating, kneading, dispersing, dissolving, encapsulation and drying — in a single mixing chamber. This one-pot method reduces interfaces and transfer points, boosts

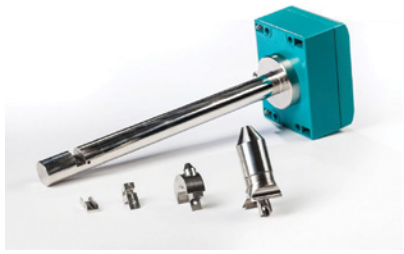
Maag Group

IPCO

Georg Fischer GmbH Piping Systems

Vaisala

Maschinenfabrik Gustav Eirich



Sopat

Fuchs Maschinen

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efficiency, and minimizes risk of contamination at the same time. Thanks to the company's highly flexible mixing principle with a rotating mixing pan and the eccentrically mounted mixing tool with variable speed and reversible direction of operation, the system ensures complete agitation of the material with every rotation of the mixing pan. Additional options include mixing under vacuum or the double-jacket design for controlled temperature conditioning (heating and cooling), and other options for the production of temperature-sensitive products or for thermally controlled processes. Hall 5.0, Stand C86 — *Maschinenfabrik Gustav Eirich GmbH & Co KG, Hardheim, Germany*
www.eirich.de

Measure particle-size distributions in line

While conventional laboratory analysis aims to determine particle size to obtain information about the quality of the final or intermediate products, inline particle measurement provides information about the manufacturing process that is often crucial. Parsum technology enables the measurement of particles in the running process — without sampling and without the need for a laboratory. The inline IPP 70-5 standard probe (photo), for example, measures particle-size distributions in all powders, granulates and bulk solids in dry and wet applications. The IPP 70-S is suitable for all processes without ATEX requirements in the fields of chemistry, foodstuffs, construction materials and more. Typical applications include fluidized beds, granulation, agglomeration, coating, spray drying, sieving, grinding and transport. The standard probe covers a particle size measurement range of 50 to 6,000 µm and handles temperatures from –20 to 100°C at pressures below 4 bars. — *Sopat GmbH, Berlin, Germany*
www.sopat.de

These blenders come in a variety of sizes

The Mixomat portfolio consists of four families: Mixomat mini (laboratory unit for container sizes up to 2 L); Mixomat A (laboratory blender for container sizes up to 26 L); Mixomat B (upright blender for container sizes up to 400 L) and Mixomat C (photo; tiltable drum blender up to max. 400 L), as well as two subgroups for cleanroom and other applications. The blenders are configured to order from standard modules. This means that one or two containers can be blended at the same time. For larger drums, it is possible to grip them directly from the pallet or other drum transport equipment and lift them into the blending position (tiltable versions). The blenders for drum sizes up to 200 L are available in a mobile version. All blenders (except the Mixomat mini) are available in Ex versions for zones 1, 21, 2 and 22. Hall 5.0, Stand B57 — *Fuchs Maschinen AG, Granges-Paccot, Switzerland*
www.fuchsag.com

The first portable respirable-dust measuring device

Dustlight (photo) is a portable device that was developed to address the widespread issue of invisible fine dust at industrial sites. Until now, existing limits to protect employees from respirable dust could not be effectively monitored because current measurement methods are time-consuming, do not provide real-time data, and require specially trained measurement engineers. Using the proven traffic-light principle, Dustlight informs every user in real-time and in a language-neutral manner whether dangerous levels of invisible fine dust are present in the air. This information is particularly important as respirable dust can linger in the air for hours after work, making the danger not immediately apparent. In the event of an elevated respirable dust level, Dustlight's light changes to yellow and urges caution. If the applicable limit value is exceeded, Dustlight lights up red and alerts the user. Hall 11.0, Stand A51 — *Latai GmbH, Munich, Germany*
www.latai.de

This vacuum pump features patented self-balancing screws

The Cobra NC 0100 B dry-screw vacuum pump (photo, p. 47) is a versatile solution for conveying sensitive and explosive gases or vapors. Its construction allows safe operation at ultimate pressures of 0.01 hPa (mbar) without

the risk of contamination from operating fluids. Its advanced dry-screw technology, including patented self-balancing screws, achieves high compression efficiency and ensures reliable operational safety. The flexibility of the Cobra enables an individual configuration that can be perfectly adapted to the demands of different processes. Thanks to their speed control and oil- and contact-free operation, they are particularly environmentally friendly and energy efficient. Hall 8.0 Stand H38 — *Busch Vacuum Solutions, Maulburg, Germany*
www.buschvacuum.com

This coupler requires no tools to seal

The new Stop-Lok Multi-Application Coupler (photo) is used for connecting piping and hoses that are used in higher heat and pressure fluid-handling applications. This evolution of traditional union couplings features a compact structure with increased functionality. No tools are required to complete the connection process. The Stop-Lok is suitable for loading and unloading fluids in chemical, water, steam, hydrocarbon and heating-and-cooling applications with pressures up to 400 psi (27.5 bars). Ease of use is found in the Stop-Lok's scalloped connection sleeve that allows for a hand-tight, tool-free connection that cannot be over-tightened. The Stop-Lok's smooth-bore coupler is constructed of 316 stainless steel and is available in ¾-, 1-, 1½-, 2- and 3-in. sizes, all of which have no variation in pipe diameter, which enables it to generate consistent non-restrictive flowrates. Hall 8.0, Stand C54 — *OPW Fluid Transfer Solutions, Nieuw-Vennep, the Netherlands*
www.opwglobal.com

Driving digitalization of functional safety to the next level

This company is not only showcasing its portfolio of safety-related automation solutions, but will also demonstrate the next stage of its digitalization strategy. Secure live connections from Frankfurt to the company's Customer Solutions Centers in Brühl and Singapore illustrate what is already possible and how the company is consistently driving forward the idea of digitalizing the safety lifecycle. Visitors will be able to perform tasks, such as simulating the control of safety systems, testing the automatic inventorying of their safety assets or carrying out automatic recurrent tests. Hall 11.1, Stand E26 — *HIMA Paul Hildebrandt GmbH, Brühl, Germany*
www.hima.com

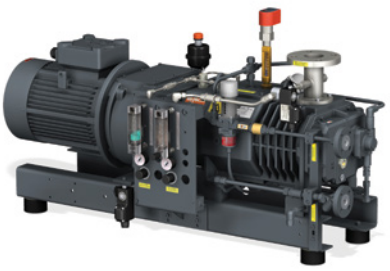
This sampler has automatic flow control

Steam and water analyzing systems (SWAS) in power plants and process-steam generators are state-of-the-art today. Monitoring a variety of parameters in the water-steam cycle allows operators to optimize water chemistry and to protect expensive investments, such as steam turbines, from corrosion. In power plants with frequent load changes, fluctuating pressures or higher particle loads caused by corrosion, valves often have to be readjusted manually to ensure sufficient sample flow. The AutoFlow (photo) enables operators to automatically maintain a constant flow under such conditions. The AutoFlow is therefore a prerequisite for the automation of new or existing sampling systems. At a process pressure of up to 400 bars, the flowrate can be kept constant at an adjusted target value between 15 and 65 L/h. Hall 11.1, Booth E63 — *Dr. Thiedig GmbH & Co. KG, Berlin, Germany*
www.thiedig.com

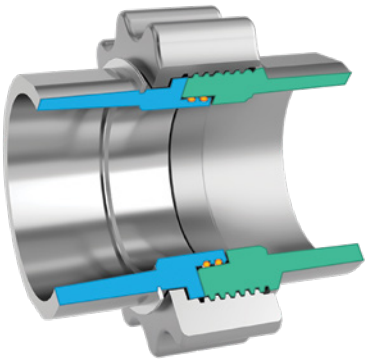
Monitoring air quality when concentrations are low

This company is launching its AP-380 series of analyzers, catering to diverse air-quality monitoring needs. The AP-380 series offers a comprehensive lineup of five models, each tailored to address specific trace-gas-monitoring requirements. These models include APMA-380 for CO, APSA-380 for SO_2, APOA-380 for O_3, APNA-380 for NOx, and APHA-380 (photo) for hydrocarbons trace-gas monitoring. Newly developed upon the foundation of the company's core technology for trace-gas analysis the AP-380 series embodies software optimization and modular design, which allows for flexible combination of modules within one analyzer, promoting usability, reduced size, and eco-friendliness. Hall 11.1, Stand E46 — *Horiba Europe, Berlin, Germany*
www.horiba.com ■

Gerald Ondrey



Busch Vacuum Solutions



OPW Fluid Transfer Solutions

Dr. Thiedig

Horiba Europe

IIoT

special advertising section

CHEMICAL ENGINEERING

Access Intelligence

Inside:

Reduce the Operating Cost of Your Plant with IIoT

By leveraging the power of MATLAB and Simulink, you can effectively acquire data from your process equipment, conduct in-depth analysis, and construct predictive models. These tools play a pivotal role in reducing the operating costs of your plant processes.

According to the US Energy Information Administration, the US chemical industry companies consumed over 7 trillion British thermal units of energy in 2023, the most of any manufacturing industry. Some energy-intensive processes, such as ethylene, nitrogenous fertilizer, chlorine, and caustic soda production, as well as HVAC and equipment maintenance, contribute to major operating costs in production plants.

Process engineering organizations have used industrial IoT (IIoT) solutions to address technical challenges and minimize operational costs. Successful IIoT programs enable engineers to build models that can predict energy loads, monitor emissions, create digital twins of their assets, predict assets' maintenance needs, and develop process control and optimization strategies. To develop these solutions, engineers acquire process data such as temperature, pressure, and flow rate from chemical process equipment, arrays of network-enabled sensors, connected instrumentation, or databases. Data volume and sharing requirements dictate how and where it is stored—on premises or in the cloud. Engineers preprocess raw data, develop visualizations and models, and ultimately create apps or dashboards to uncover insights and support potential actions.

Many process and production engineers use tools developed in MATLAB and Simulink to build IIoT solutions that minimize operational costs. By developing digital twin models to create virtual representations of operating devices and processes in Simulink, engineers have contributed to optimizing plant, device, and process operations promptly and effectively.

Deriving actionable insights from large data sets can be a time-consuming process. However, with the aid of MATLAB, process engineers expedite data-driven model building by predicting the energy demand and emissions from chemical processes, as well as the remaining useful life (RUL) of critical equipment, including heat exchangers, pumps, and compressors. These optimization models are instrumental in minimizing the cost and environmental impact of processing operations.

MathWorks supports process engineers with end-to-end IIoT solutions and support to acquire sensor data; create first-principles, data-driven, or hybrid models; and develop control and optimization algorithms and deploy them on hardware or actionable apps and dashboards for real-time analysis and production monitoring.

www.mathworks.com/iot

New Monitor/Controllers Feature 7 Parameters in 1

Myron L Company multi-parameter monitor/controllers™ are easy to install, easy to use, and do the job of multiple monitors and controllers.

900 Series Multi-Parameter Monitor/Controllers include everything required to simplify water quality management across industrial applications in a single user-intuitive instrument. Simultaneously monitor and control critical water quality parameters through multiple inputs/outputs with the legendary accuracy and reliability the **Myron L Company** has come to be known for. 900 Series Monitor/Controllers feature a simple-to-use LCD touchscreen Graphical User Interface along with pluggable terminal blocks for quick and easy equipment installation and configuration.

Monitor 7 critical water quality parameters simultaneously from easily configured inputs: 2 Conductivity/Resistivity/TDS/Salinity; 1 pre-amplified pH/ORP; 1 BNC pH/ORP; 1 0-20/4-20 mA; 1 RTD Temperature; and 1 Flow/Pulse. % Rejection is available as a derived value. For maximum accuracy, the Conductivity and TDS functions allow you to select the solution type used to model the solution under test: KCl, NaCl, or Myron L's own 442 Natural Water™ Standard. Or program a "User" solution mode when solution constituents and behavior are known. Temperature compensation is automatic to 25°C or can be disabled by the user as required. The pH/ORP input channel is designed for use with Myron L pre-amplified pH and ORP sensors. These sensors contain precision circuitry that increases accuracy and permits application of the sensors over greater distances. The 0-20/4-20 mA input allows user-defined 0 to full scale values and units of measure for a wide array of sensor types. Electronic or wet calibrations are easy to perform.

Outputs include up to 3 relays; 2 remote alarms; 1 0-20/4-20 mA; 1 0-5/0-10 VDC; and 1 RS-485 ASCII Serial Output. Relays output to any user-supplied control equipment requiring up to 250V each and can trigger on any input parameter. The 0-20/4-20 mA output can transmit a signal for any input parameter. 0-5/0-10 VDC can be scaled to optimize resolution and can output to a recorder, PLC, SCADA system, etc. 0-1 VDC is possible with optional resistor. Hysteresis values can be specified by the user or automatically set by the 900 Series to prevent chatter.

The flow switch input can disable all relay outputs when triggered by loss of flow. User adjustable cell constant (Conductivity/Resistivity/TDS/Salinity) and sensor cable length (Conductivity/Resistivity/TDS/Salinity, pH and RTD) increase accuracy. Administrator and Operator password protection levels prevent unwanted tampering. The brightly colored red, yellow, and/or blue LCD background instantly alerts the user to the solution status. A ¼ DIN Size Chassis makes it easy to mount. **www.myronl.com**

Trillium Flow Technologies Unleashes IIoT Potential

Redefining Valve Performance and Maintenance

Trillium Flow Technologies' new smart valve technology harnesses big data and capitalizes on the digital transformation efforts seen in industrial markets as IIOT gains traction. Meticulously designed to offer comprehensive care for your plant's existing systems, our cutting-edge solution delivers real-time monitoring capabilities, empowering you to undertake planned preventive maintenance, reduce downtime, and significantly enhance productivity.

Our technology encompasses a simple bolt-on approach, upgrading the existing valve by collecting operational data using an interactive dashboard. The technology provides secure connectivity and real-time data analysis. Process data is gathered from Trilliuminstalled sensors or existing infrastructure, with wireless pressure transducers installed on upstream and downstream pipework. The predictive algorithm then processes live pressure readings and flow meter outputs to map valve performance. Harnessing the power of control valves with embedded sensors, our system utilizes the innovative SMART algorithm to predict performance degradation. This enables you to schedule repair or replacement in a controlled manner, effectively avoiding the need for ad-hoc maintenance work and costly emergency valve repairs. User-friendly software eliminates the need to review extensive diagnostic data and offers clear guidance on failure types and part replacement planning, enabling efficient resource deployment and just-in-time spare part delivery. An interactive dashboard provides a comprehensive overview of equipment performance, with the flexibility to delve deeper into areas of concern – while clear visuals and alarms offer crucial information for decision-making on underperforming assets. Our scalable gateway infrastructure allows for remote real- time monitoring of hundreds of assets worldwide from a single location. The system can function as a standalone cloud station or seamlessly integrate into your existing infrastructure, ensuring secure data transfer through a cloud environment and protecting equipment performance data during local and remote access. Third-party hardware interfaces can be created locally or in the cloud to gather process information to support the algorithm.

By leveraging Trillium's remote monitoring capabilities, you can eliminate the extra cost of on-site valve expertise. The system maintains direct contact with the Trillium services division, providing rapid response instructions for detected failures and ensuring swift problem resolution. In addition, our team is always available to conduct thorough analyses and recommend the best solutions to resolve issues.

Experience the plant maintenance and productivity revolution with Trillium's advanced digital transformation technology, expertly crafted for the modern industrial world. Learn more at: **www.trilliumflow.com/smart**

Improve Vacuum System Uptime with IoT Monitoring Technology

In today's fast-paced industrial landscape, process control is critical. Digital condition monitoring helps your operations by keeping an eye on your equipment's performance. With the ability to monitor specific parameters such as vacuum levels, power absorption and ambient temperature, you gain more advanced control over your production processes. By capturing and storing this critical data, you pave the way for proactive maintenance strategies, effectively mitigating costly downtime.

OTTO digital monitoring technology from Busch Vacuum Solutions seamlessly retrofits into existing vacuum systems. OTTO IoT kits feature an integrated electronic SIM card for secure data transmission to the **Busch** cloud. Whether deployed independently or integrated into the Busch control system, OTTO ensures heightened reliability and efficiency, upscaling your approach to equipment monitoring.

But OTTO is more than just a monitoring tool—it's a proactive guardian of your operations. With its advanced early problem detection capabilities, OTTO minimizes unplanned downtime, safeguarding process safety and enhancing productivity like never before.

Experience the future with Busch's innovative digital monitory tools. Don't let uncertainty dictate your production schedule—contact us today to learn more about how Busch can empower your operations.

www.buschusa.com

CHEMICAL ENGINEERING
ESSENTIALS FOR THE CPI PROFESSIONAL

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Written for engineers by engineers, *Chemical Engineering* delivers solid engineering essentials and developing industry trends to keep its readers abreast of everything they need to keep their facilities running smoothly.

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Pairing First-principles Simulation with AI

Chemstations is partnering with Ingenero Technologies at ACHEMA 2024 to highlight the critical contribution of first-principles process simulation in integrating the chemical industry with artificial intelligence.

The initial design and operation of most chemical plants today involves a first-principles model in a process simulator. Early results are typically steady-state 'snapshots' of the process at a single operating condition; at the operational level, though, high-fidelity modeling of all possible dynamic conditions would become a strain on time and resources.

Engineers and operators need an accurate picture of realistic operating conditions to ensure the best outcomes. A first-principles simulator can find a theoretical optimum for a process, and operations data can show how well that optimum is being met. When achieving the optimum in the real world proves difficult, AI tools can help make the operational goal a reality.

By analyzing real-time plant data and comparing it to historical data and the theoretical optimum from the first-principles model, AI can suggest operational changes to the original model. This approach closes the loop between first-principles models and AI applications, enhancing the engineer's predictive capabilities and bridging the gap between theoretical understanding and operational realities.

www.chemstations.com

ACHEMA 2024 Presentation:

The Value of First-principles Process Simulation in the AI Era

Chemstations INGENERO

11 June 2024
12:00 PM
Siemens Digital Innovation Stage 11.0

Chemstations
SCAN ME

2024

special advertising section

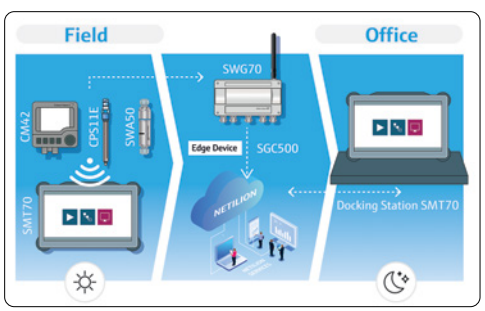
Inside:

Empower Your Processes with Digitalization

Unlock the potential of your industry with **Endress+Hauser**'s innovative solutions. Say goodbye to outdated analog systems and embrace the future of data-driven decision-making. With the digitalization of your field layer, efficiency and safety reach new heights.

Transitioning to the Future

In the fast-paced world of process industries, staying ahead means harnessing the power of data. The era of analog signals dominating the market is fading. Endress+Hauser introduces a new frontier: smart sensors that redefine control, verification, and testing. It's time to revolutionize your processes.



Starting with pH measurement

Embark on your digital transformation journey with pH measurement. Why? It's the fundamental starting point:

1. Frequent Maintenance: Vital for plant operations.
2. Advanced Diagnostics: Enables data-based decisions.
3. HART Capability: Seamlessly integrates into modern systems.

Seamless Integration, Enhanced Efficiency

Equip your devices with WirelessHART dongles for hazardous areas. Endress+Hauser's FieldPort SWA50 ensures a secure connection to our cloud services. Say hello to refined maintenance processes and optimized operating ranges, minimizing uncertainties for peak efficiency.

The Solution: Field Xpert SMT70 Tablet

Meet the Ex-Zone 1 Field Xpert SMT70 Tablet with FieldCare SFE500. It's more than a device; it's a game-changer. Collect data directly from pH probes in the field, sync effortlessly with Netilion in the cloud, and unveil a world of insights. Analyze, interpret, and optimize with ease.

Elevate Your Processes Today

With Endress+Hauser, it's not just about technology; it's about empowerment. Make data-driven decisions that elevate your processes. Whether in hazardous areas or standard operations, our solutions lead the way to efficiency and safety.

Your Path to Digital Excellence

Transforming your processes is no longer a distant dream. Endress+Hauser puts the power in your hands. Say yes to digitalization and revolutionize the way you operate. It's time to embrace the future, starting from the field layer up. Where will you begin?

https://eh.digital/ph-measurement

EKATO introduces its innovative Hydrogenation Plant for Active Pharmaceutical Ingredient Manufacturing

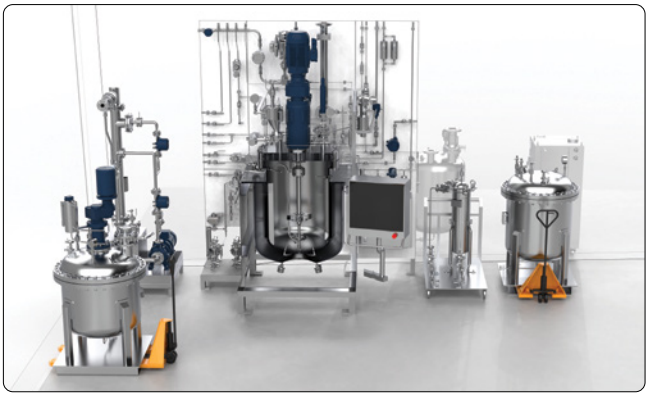
EKATO GROUP introduces its innovative hydrogenation plant, designed for Active Pharmaceutical Ingredient (API) manufacturing, with notable features: customizable configuration based on a versatile, modular plant concept. This technology marks a significant advancement in pharmaceutical production, prioritizing adaptability, flexibility, and efficiency.

Tailored for small and medium batch sizes, the plant addresses the specific needs of small-scale and launch-scale facilities handling a wide range of different materials and chemistries. Its exceptional process flexibility ensures efficient adaptation and quick reconfiguration during production campaign changeovers.

The mobility and flexibility of the product preparation tank, product filter and product receiver, which are available in different material and sizes, facilitate adaptation to diverse API and process requirements, empowering manufacturers to customize production processes within shortest times and at lowest cost. The scalability of the powerful EKATO Hydrogenation Reactor with its unique Combined Gassing System® supports safe and fast transitions to larger production capacities, ensuring operational continuity and growth scalability.

Safety remains a priority when handling hydrogen at high pressure, with advanced safety features and automated controls ensuring precise and secure production operations.

Uncompromising quality and safety are at the forefront of the plant's design. It adheres to the strictest regulatory standards and provides comprehensive qualification options, guaranteeing compliance with pharmaceutical industry regulations and the highest product quality. The hygienic design maintains the highest cleanliness standards, preventing product cross-contamination.



With compact modularity and customizable configuration as core features, the EKATO Hydrogenation Plant offers process flexibility, fast campaign changeovers and affordability for the production of high-value pharmaceutical ingredients in small and medium batch sizes.

Contact EKATO GROUP for more information on how this pioneering, modular plant concept can enhance your API manufacturing operations.

www.ekato.com

Solutions for a sustainable process industry at ACHEMA 2024

At this year's ACHEMA, everything at **Phoenix Contact** in Hall 11.1, Stand A31, will revolve around how to establish a sustainable process industry and achieve the related climate targets. The industry is facing various challenges – including the need for cost savings in processes, greater efficiency and flexibility in modularization, and the use of sustainable resources for system operations. The good news is that with the current development of technology standards and modularization approaches, the right solutions are available when it comes to energy efficiency and reducing CO_2 emissions in the process industry.

This is why Phoenix Contact is working together with various partners on the further development of the MTP approach. An MTP live demonstrator will be exhibited at the trade fair stand with the company Pruess. The new MTP concept for functional safety is also taken into account here in the form of a mobile preparation container for Ex zone 1. The same will be demonstrated at the DI water station together with the TU Dresden University. This water treatment station for electrolysis plants is in line with Phoenix Contact's vision of a future with the All Electric Society and the associated power-to-X range, which will be on display at the trade fair stand.

Data transmission in the process industry is an elementary factor when it comes to the integration of digital fieldbuses. Against the background of complete digital communication right down to the field level, Phoenix Contact's new Ethernet APL switch enables the direct two-wire Ethernet connection of APL field devices in the Ex zones. This means that not only the process data, but also other valuable device information can be used directly from the field level. This will be presented on an APL multi-vendor panel. Other demonstrators will be showing monitoring and surveillance solutions that enable predictive maintenance based on NOA.

www.phoenixcontact.com

10” tablet for performance and comfort in hazardous areas

Pepperl+Fuchs presents new 10” tablet Tab-Ex 04 Pro DZ2 and D2

Pepperl+Fuchs, a pioneer in mobile devices for hazardous areas, expands its Tab-Ex tablet series with the Tab-Ex 04 Pro DZ2/D2, based on the rugged Samsung Galaxy TabActive4 Pro. The tablet supports innovative applications such as IIoT or augmented reality while providing users outside of the field with a unique desktop-like experience via DeX Mode.

The Tab-Ex 04 Pro DZ2/D2 simplifies data exchange with SCADA/DCS systems, ERP systems, project management systems, and computer-aided system planning. Despite its large 10” screen, the versatile tablet is compact, lightweight, and ideal for a wide range of tasks such as inventory, material tracking, maintenance, and supply chain and asset management.

Strong Partners for Any Task

Tab-Ex 04 Pro DZ2/D2 is part of the comprehensive Pepperl+Fuchs portfolio for the connected mobile worker in hazardous areas which includes smartphones, tablets, peripherals, and software applications. Mobile users can integrate additional Tab-Ex solution packages from a single source, such as Pepperl+Fuchs data capture, measurement and monitoring devices, headsets, AutoID, and Bluetooth beacons for tracking. The cooperation with Samsung in the design phase makes for a long product life cycle, state-of-the-art technology, reliability, and security thanks to Samsung Knox.

In 2023, Pepperl+Fuchs confirmed its consultancy and support services by achieving Silver Partner status in the Android Enterprise Partner Program, meeting the highest requirements Google has set for use in the industrial sector and enterprise environments.

www.pepperl-fuchs.com

Ex-proof mobile devices and solutions for process optimization

World market and innovation leader **i.safe MOBILE** takes advantage of ACHEMA as the most important international trade fair in its field to present its products to international trade visitors from the chemical, pharmaceutical and other important industry sectors.

The company provides an insight into the latest developments:

- The new 10.1-inch 5G Android and Windows tablet IS940.1 / IS945.1 for seamless data communication in the process industry
- The first 5G radio IS440.1 for safe PoC communication via public, campus networks or Wi-Fi in hazardous environments
- The Android-based RealWear Navigator Z1, an intrinsically safe head-mounted wearable of i.safe MOBILE and RealWear for hands-free operation in remote training and field service tasks
- The IS540.x 5G industry smartphone with a clear 6-inch full HD display, 48 MP main camera and high-quality processor for industrial applications like predictive maintenance
- The IS-VS1A.1 mobile inspection system for leak detection in valves, combining acoustic emission sensors with the IS540.1 smartphone and the software of Senseven
- The IS-SW1.1 explosion-protected industrial smartwatch for ATEX/IECEx zones 1/21, enhancing employee safety and organization.

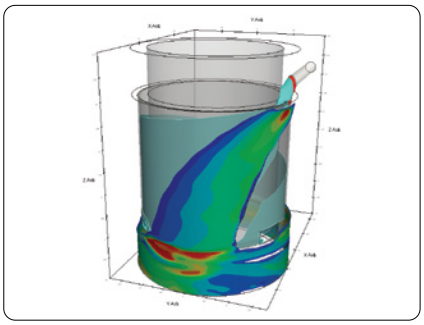
These cutting-edge products cater to the demanding needs of industrial environments, offering advanced features like fast data processing, intuitive operation and high-quality image capture.

Visit i.safe MOBILE at ACHEMA: hall 11.1, booth B26. **www.isafe-mobile.com**

Perfect Liquid Distribution in Thin Film Evaporators

Special applications need special design! This also holds for thin film evaporators (TFE), which are in use for a wide range of thermal separation tasks. TFEs are the favored equipment for continuous processing of challenging liquid mixtures.

Distributing liquid evenly onto the inner heated surface of a cylindrical or conical TFE poses a significant challenge, particularly with liquids of low viscosities below a few ten times the viscosity of water. A distribution device mounted to the rotor spreads the liquid evenly across the periphery. Then, the blades fitted at the rotor apply the liquid as a thin film of minimum 0.5mm thickness over the heat transfer surface. Conventional distribution systems may struggle to ensure uniform application, leading to inefficiencies and potential overdesign of equipment.



Recognizing this challenge, **Buss-SMS-Canzler** developed a ground breaking liquid distribution system which guarantees the even distribution to the inner heated surface of the evaporator as already successfully implemented in SMS-short path evaporators.

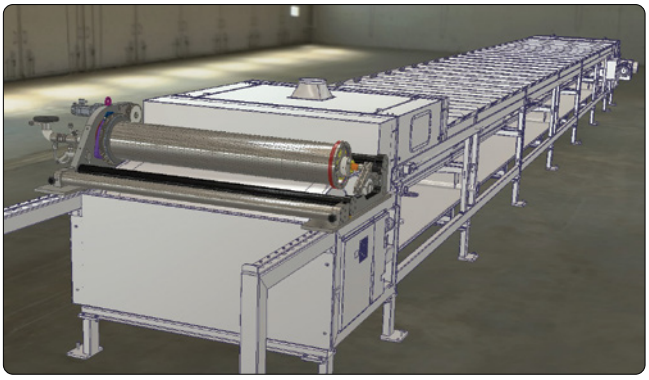
The figure above shows a computational fluid dynamic (CFD) calculation of the new liquid distributor in operation. The entire heating surface beneath the distributor is uniformly covered with a liquid film. This results in optimal usage of the equipment and best performance of the evaporator. Finally, it saves costs by eliminating the need for overdesigned TFEs caused by imperfect liquid distribution.

With Buss-SMS-Canzler’s innovative solution, TFEs can achieve unparalleled performance and efficiency.

sms-vt.com

High capacity pastillation of low viscosity slurry products

IPCO expands Rotoform range with high yield, low maintenance XG model for granulation of suspensions



Chemical processing systems manufacturer **IPCO** has announced the introduction of the Rotoform XG, a high capacity pastillation system offering superior handling of low viscosity melts containing solid particles, and significantly easier cleaning and maintenance.

Designed for applications such as sulphur bentonite, NPK and other fertilizers as well as urea mixes, the new model can convert solid-containing melts into high quality pastilles from 2-4 mm diameter. The XG is also able to process catalysts, wax suspensions and other products containing solid additives or contaminant particles up to 200 *µm in size*.

Offering twice the throughput rates of the standard Rotoform 4G model, the XG is capable of processing slurries with viscosities lower than 100 mPas.

The design follows the same basic principle that has seen more than 2500 Rotoform installations completed since the process was introduced in the late 1970s. Liquid product is delivered to a stator then deposited in drop form via a rotating perforated outer shell onto a continuously running steel cooling belt.

However, the XG incorporates a number of productivity-enhancing innovations including a sliding base frame that allows the Rotoform to be pulled out for easy access, and a completely new stator design that makes cleaning and maintenance much easier. A new bearing system with fewer parts and increased wear resistance further reduces maintenance requirements.

"This is a major development in terms of handling slurry and abrasive products," explains Ulrich Nanz, Global Product Manager, Chemicals, at IPCO. "The high capacity of the system maximises productivity, while easier cleaning and maintenance equates to lower costs."

The speed of the Rotoform is synchronised with that of the belt ensuring gentle deposition of the droplets. Heat released during solidification is transferred via the steel belt to cooling water sprayed underneath, so there is no risk of cross-contamination and the water can be cooled and re-used.

www.ipco.com

High-pressure Venturi scrubbers for clean hydrogen

Cooling – scrubbing – dedusting – humidifying – mixing

Alongside Venturi scrubbers' conventional usages, there's rising demand (especially by some high-pressure processes) for them to perform and make improvements to cleaning, dedusting, humidifying, and mixing tasks. Examples can be found in syngas treatment and production, coal gasification and conversion to industrial alcohol/ether.

Syngas production, i.e. the industrial production of gas mixtures and H_2, are just examples of the wide range of potential applications. The composition of the primary gases varies depending on the application, but mostly consists of H_2, CO, CO_2, N_2, and H_2O which virtually always contain a certain amount of process-related soot. Water is used as the scrubbing medium. Körting high-pressure Venturi scrubbers are used in numerous processes e.g. Steam methane reforming (SMR), Multi-purpose gasification (MPG®) and others.

Over 40 years of experience

The first projects with high-pressure Venturi scrubbers were carried out back in 1978. **Körting Hannover** GmbH draws on decades of experience with jet ejector technology and gas scrubbers to design this sophisticated process-engineering equipment. To come up with the best customised solutions, we collaborate with our in-house development department to conduct CFD simulations and trials on our own test rig.

To ensure long service lives and minimal maintenance, high-pressure Venturi scrubbers are often made of, or clad with special materials or special material combinations, such as stainless steel or duplex stainless steel and subjected to stringent quality assurance inspections.

Special technical features:
- Pressure: 1 - 80 bar
- Material: wall thicknesses from 10 - 60 mm
- Flanges: 600 - 900 lbs.
- Temperatures: 200 – 400 °C
- Nominal widths: DN 200 – 1200
- Gas inlet: axial (alternatively lateral at 90°)

Due to high-precision manufacturing, predominantly at the Hanover site in Germany, Körting ensures that high-pressure Venturi scrubbers are designed and made based on the requirements of the customer and processes, as well as the necessary specifications and codes. The appropriate process-engineering and mechanical design calculations are also carried out.

www.koerting.de

LiB production: mixers for laboratory and Gigafactory

Customized particle design as the key to success

Dr. Stefan Gerl*

**The author is head of process engineering at Maschinenfabrik Gustav Eirich GmbH & Co. KG, Hardheim, stefan.gerl@eirich.de*

In the production of li-ion batteries, **Eirich** intensive mixers are convincing all along the line: from the functionalization of active material particles to the production of coating compounds for separators as well as wet to dry electrode mixtures. The adaptation of operating parameters and mode of operation alone enables users to fulfill a wide variety of tasks with a single mixer type.

Particle coating, a central basic operation in LiB production

Coating of particle systems and suspending for the production of wet electrode mixtures are central basic operations of LiB production. Eirich intensive mixers in their design as Eirich MixSolver® with a horizontally arranged mixing vessel are ideally suited for suspending, but as mixers with an inclined mixing vessel they are equally well suited for coating, but above all granulating particle systems.

Coating and thus functionalizing active material particles with different nano-structured particles such as aerosils or conductive carbon blacks is a common intermediate step in the production or use of active materials. If these processes are to be carried out completely dry, without the detour via suspensions and spraying processes, mixers are needed that generate high shear rates in the powder bulk. The microgranulation die patented by Eirich also shows excellent performance in this task. The optimized shear field at the outer edges of the die breaks up the agglomerated nanoparticles so well at the appropriately selected die speed that they can dock onto the surface of the active material particles and coat them in the best possible way within a very short time.

Fig. 1: Simple scale-up from laboratory to gigafactory, e.g. from the universal 1l laboratory mixer EL1 to the 900l intensive mixer RV16 or MixSolverÒ RV12 for large-scale production. Source: Eirich

Macroscopically, this change at the particle surface is expressed by a noticeable change in the bulk density and tamped density, but also in the flow properties of the bulk. Depending on the selected mold speed and mixing time, particle systems can be designed in a simple way.

Visit us at ACHEMA Halle 5.0 Stand 86.

www.eirich.com

Changing the material properties of powdery and liquid products

Agglomeration technology: AMANDUS KAHL presents special plants at ACHEMA

In addition to the proven pelleting technology, **AMANDUS KAHL** will also showcase its extensive expertise in fluidised bed technology at this year's ACHEMA in Frankfurt. From 10 to 14 June, the machine manufacturer from Reinbek/Germany will be exhibiting its flat die pellet mills type 14-175 and 33-600, as well as the flexible laboratory fluidised bed plant LFB Batch mini.

At ACHEMA, innovation takes centre stage. From process engineering to pharmaceutical engineering and to laboratory technology - this exhibition provides a platform for the most important innovation drivers in the process industries. With its special plants in the field of fluidised bed technology, AMANDUS KAHL offers its customers in the chemical, pharmaceutical, food and feed industries as well as in the biotechnology sector various processes to modify the material properties of powdery or liquid products. A gas, usually air, flows through the solid particles from below. The intensive movement of the particles produces the so-called fluidised bed. It provides ideal conditions for further processing, including agglomeration, spray granulation, coating or micro-encapsulation.

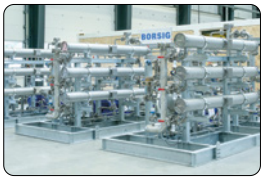
AMANDUS KAHL fluidised bed systems are versatile and flexible. Depending on the input product, quantity and product requirements, fluidised bed technology can be used in Conti-FB plants as a continuous process or in Batch-FB plants a batchwise process. In the batch process - unlike in the continuous process - the powdery products are processed batchwise, which is particularly suitable for the manufacture of small production quantities. Users can flexibly select the process parameters for drying, agglomerating, spray granulating, micro-encapsulating and coating powders, granules and pellets.

"Pelletpresse 33-600": The pellet mill 33-600 can optionally be GMP certified for pharmaceutical applications.

AMANDUS KAHL pellet mills are particularly suitable for pelleting dusty products with a low bulk density and which are difficult to dose. Due to its compact size, the pellet mill 14-175 is mainly used on a laboratory scale. Like the pellet mill 33-600, it can be GMP certified for applications in the pharmaceutical industry. Further information on all pelleting and fluidised bed plants is available at stand B47 in Hall 6.1.

www.akahl.com/en/industries/fluidized-bed-technologies

Organic Solvent Nanofiltration – small membranes with great potential.



BORSIG's innovative technologies in the field of solvent-resistant polymer membranes offer an energy-, raw material- and cost-efficient alternative to thermal separation processes.

The Organic Solvent Nanofiltration (OSN) opens up completely new potential to meet the increasing demand for sustainable process solutions in industry. **BORSIG** Membrane Technology GmbH already has extensive expertise and references in this field.

The system concepts of BORSIG Membrane Technology GmbH are based on new solvent-resistant polymer membranes, which are already successfully used in many industrial processes. These OSN membranes are an innovative tool for the separation and fractionation of organic mixtures and solvent-containing process streams. The use of OSN membranes allows the separation of organic liquids under moderate operating conditions (temperature, pressure) with low energy consumption compared to purely thermal processes.

OSN applications include the concentration, removal and separation of dissolved additives, impurities, valuable substances and (intermediate) products from liquid organic process streams.

The product portfolio therefore covers a wide range of interesting applications:

Oil & gas industry
- (Bio-)fuel processing
- Crude oil and LNG processing
- Lube and waste oil processing

Fine chemicals
- Homogeneous catalyst recovery
- Mother liquor concentration

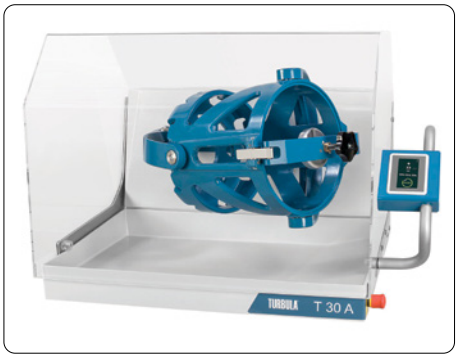
Life science and pharmaceutical industry
- Decolouration and purification of essential oils
- Decolouration and purification of hemp extracts
- API or protein purification

Other applications
- Solvent purification and recovery

ACHEMA, Hall 4.0 Booth B26

www.borsig.de/mt

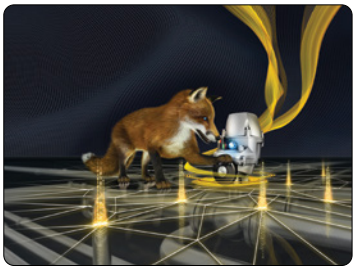
3D shaker mixers for highest homogeneity



Our 3D shaker mixers with their closed and safe systems and their optimised mixing movement stand out from existing alternatives. Our TURBULA (0.1-55 l) and dyna-MIX (40-1000 l) series have been developed for users in industry (e.g. pharmaceuticals, food & beverage, cosmetics), who want to mix their product efficiently and guaranteed as homogeneous – whether solid-solid, liquid-solid or liquid-liquid. The high mixing efficiency of these 3D shaker mixers results in the shortest mixing times and thus an extremely gentle mixing process. At ACHEMA, we will be launching TURBULA T 30 A, the next generation of our mid-range mixers. Container sizes up to 30 l can be used. The intuitive operation panel touch screen with user-friendly interface and a PLC-based control system makes the 3D shaker mixer an innovative product for your application. Find out more at ACHEMA Hall 6.0 Booth C5!

www.wab-group.com

Smart and small actuators for future-proof process automation



AUMA presents its new PROFOX-X actuators, providing safe and precise valve control in potentially explosive atmospheres, including hydrogen.

AUMA presents its latest innovations in valve automation at ACHEMA.

The **AUMA** stand this year focuses on small and smart actuator series, which are ideally suited to meet challenging valve control requirements in process applications.

Actuators in the successful PROFOX series, for example, offer high-precision automation solutions for all valve types in the lower torque and thrust ranges. Easy to integrate and sustainable, these versatile actuators are key enablers of digital transformation in modern process plants.

AUMA's PROFOX series has recently been expanded with a new explosion-proof version: PROFOX-X actuators have ATEX and IECEx certifications for the highest gas group, IIC T4, and ensure safe operation in potentially explosive atmospheres, including hydrogen applications.

Both PROFOX and PROFOX-X actuators support fieldbus and Industrial Ethernet communication, making host system integration flexible and easy. The actuators' embedded data logging is a perfect match for CORALINK, AUMA's digital ecosystem, enabling advanced diagnostics and predictive maintenance.

Motor speed is adjustable, ensuring fast and precise positioning. Soft start and soft stop functionalities increase valve lifetime. High-quality "made in Germany" design and construction, wide temperature range and premium corrosion protection ensure high reliability and long service life under tough process conditions. Visit AUMA at ACHEMA: hall 8 / stand C23

www.profox.auma.com

TubeEndProtection- Effective protection for discharge pipes

Pressure relief fittings such as rupture discs and safety valves are crucial safety components in a variety of industrial systems. These valves are used to protect systems and processes from internal overpressure by providing controlled pressure relief to prevent potentially dangerous situations. They are used in a wide range of industries, from petrochemicals to food processing and power generation.

The advantages at a glance:

- Effective protection of blow-off pipes against weather and environmental influences
- Cost-efficient thanks to quick and easy installation
- Made of PE fleece - no perfluorinated and polyfluorinated alkyl compounds (PFAS)
- Visual detection when a safety device responds Sicherheitseinrichtung
- Breathability - prevents pressure build-up and minimises condensation

In the outdoor area of ACHEMA this year you can expect a live demonstration by Roland Bunse (Managing Director **REMBE®** Research + Technology Centre GmbH) in cooperation with a world-famous star guest. In the indoor area you will find us at stand C4, hall 9.

www.rembe.de

Robust technology solves chemical industry challenges

In the chemical industry, measuring precise liquid concentration or density inline is important. **Vaisala Polaris**, our pioneering optical inline process refractometer, delivers real-time data for advanced process control. Whether it's raw materials or finished products, Polaris ensures accuracy, stability, and efficiency.

Moisture matters Too

Smooth drying operations hinge on moisture analysis. Vaisala's Indigo family, customizable and modular, measures relative humidity, absolute humidity, dew point, and temperature. Chemicals manufacturer can be certain there is no quality deviations in the produced powdered chemicals.

Meet us at Achema 2024 in hall 11-1, stand C76, and exchange ideas on the latest trends in the chemical industry. Vaisala's experts will be happy to discuss the opportunities provided by accurate data from in-line liquid process measurement, and products and solutions for measuring and monitoring critical environmental parameters.

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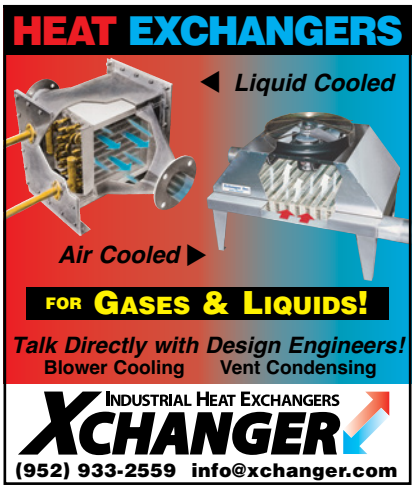

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June 2024; VOL. 131; NO. 6
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Economic Indicators

2022 2023 2024

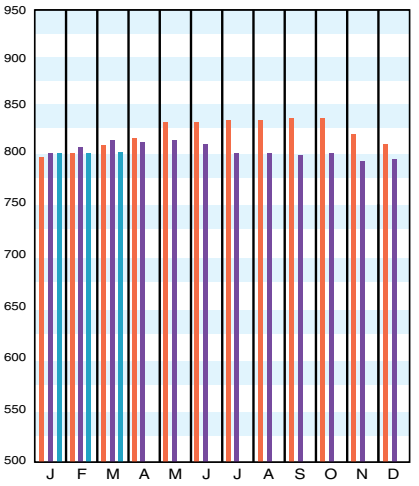
Download the CEPCI two weeks sooner at www.chemengonline.com/pci

CHEMICAL ENGINEERING PLANT COST INDEX® (CEPCI)

(1957–59 = 100)	Mar. '24 Prelim.	Feb. '24 Final	Mar. '23 Final
CE Index	800.7	800.0	799.1
Equipment	1,006.3	1,005.1	1,008.5
Heat exchangers & tanks	810.6	811.5	821.1
Process machinery	1,033.9	1,033.1	1,032.9
Pipe, valves & fittings	1,342.5	1,349.9	1,401.7
Process instruments	569.9	568.3	566.4
Pumps & compressors	1,537.8	1,518.2	1,391.8
Electrical equipment	822.8	811.8	794.8
Structural supports & misc.	1,131.2	1,127.8	1,119.5
Construction labor	374.7	372.5	361.7
Buildings	812.6	820.9	805.4
Engineering & supervision	315.5	316.1	313.0

Annual Index:
2016 = 541.7
2017 = 567.5
2018 = 603.1
2019 = 607.5
2020 = 596.2
2021 = 708.8
2022 = 816.0
2023 = 797.9

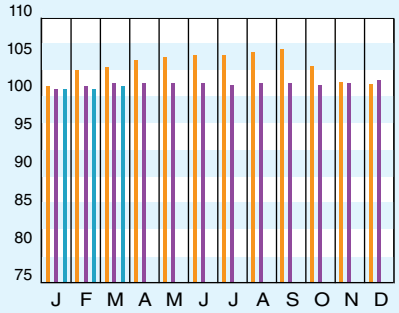
Starting in April 2007, several data series for labor and compressors were converted to accommodate series IDs discontinued by the U.S. Bureau of Labor Statistics (BLS). Starting in March 2018, the data series for chemical industry special machinery was replaced because the series was discontinued by BLS (see *Chem. Eng.*, April 2018, p. 76–77.)



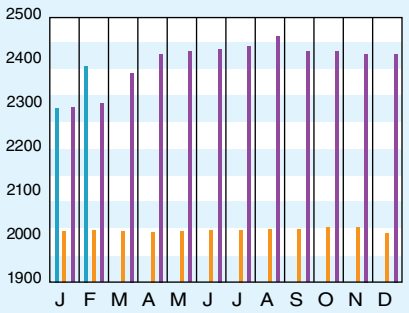
CURRENT BUSINESS INDICATORS

	LATEST		PREVIOUS		YEAR AGO	
CPI output index (2017 = 100)	Mar. '24 =	99.4	Feb. '24 =	99.1	Mar. '23 =	99.3
CPI value of output, $ billions	Feb. '24 =	2,414.3	Jan. '24 =	2,355.2	Feb. '23 =	2,421.0
CPI operating rate, %	Mar. '24 =	78.5	Feb. '24 =	78.3	Mar. '23 =	79.4
Producer prices, industrial chemicals (1982 = 100)	Mar. '24 =	297.7	Feb. '24 =	296.3	Mar. '23 =	328.2
Industrial Production in Manufacturing (2017 =100)*	Mar. '24 =	99.9	Feb. '24 =	99.4	Mar. '23 =	99.1
Hourly earnings index, chemical & allied products (1992 = 100)	Feb. '24 =	225.7	Jan. '24 =	230.3	Feb. '23 =	210.7
Productivity index, chemicals & allied products (1992 = 100)	Mar. '24 =	92.9	Feb. '24 =	94.3	Mar. '23 =	94.0

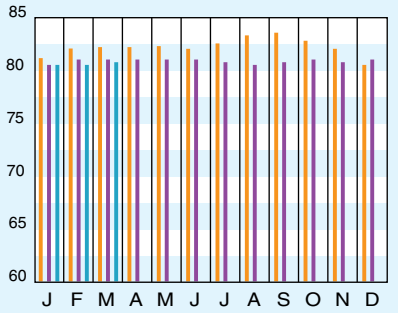
CPI OUTPUT INDEX (2017 = 100)†



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2012 to 2017
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

CURRENT TRENDS

The preliminary value for the *CE* Plant Cost Index (CEPCI; top) for March 2024 (most recent available) is higher than the previous month's value, albeit by a very small margin. The small uptick is the third consecutive monthly rise. In March, small increases were observed in the Equipment and Construction Labor subindices, while the Engineering & Supervision and Building subindices saw very small decreases. The current CEPCI value now sits at 0.2% higher than the corresponding value from March 2023. Meanwhile, the Current Business Indicators (middle) show small increases in the CPI output index and the CPI operating rate for March 2024, and an increase in the CPI value of output for February 2024.